THE FEEDING ECOLOGY OF THE CYPRUS MOUFLON *Ovis orientalis* Gmelin 1774, IN THE PAPHOS FOREST, CYPRUS.

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I hereby declare that this dissertation is the result of my own work and the data presented here are my own. No part of this dissertation has been submitted to this or any other University for any degree or diploma. The work presented here was carried out from the Deparment of Forestry and Natural Resources under the supervision of Dr. Peter Jones.

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ABSTRACT

The Cyprus mouflon *Ovis orientalis* Gmelin 1774 is found in the Paphos forest of Cyprus, a mountainous area dominated by *Pinus brutia*, and it is one of the few wild sheep living in a forested habitat. Their feeding ecology was examined with particular reference to the pattern of seasonality found in the Mediterranean, which is that of mild wet winters and hot, dry summers. The timing of the rains influence the timing of the quantity and nutritional quality of the food resources for the mouflon in Cyprus. The nutritional quality, availability, consumption and degree of selectivity of different plants was examined. Plants of the herb layer (grasses, forbs and non-graminaceous monocotyledonous plants) were highly digestible and had a high crude protein content during the wet season. Woody browse plants had their highest digestibilities and crude protein content later in the year, during late spring and early summer. Mouflon thus had access to high quality food during winter. During summer the food supply was less abundant, less digestible, less proteinaceous and contained less phosphorus than during the wet season. Using faecal analysis, it was found that the animals ate mostly grasses, forbs and non-graminaceous monocots all year. However, during the summer, a higher proportion of broadleaved trees was eaten than during the wet season. Concurrently a lower proportion of grasses was eaten, probably because broadleaved trees in summer contained much more crude protein and were more digestible than grasses. Forbs were eaten in slightly higher proportions in summer than during the wet season, and the remained fairly digestible and proteinaceous during the summer. Pine and oak (*Quercus alnifolia*) trees were avoided by mouflon.

Examination of diet quality by nitrogen analysis of the faeces showed that the quality of the mouflons' diet was lowest during late summer and early autumn. The estimated crude protein intake during August, September and October was close to, or in some cases below, the maintenance level for ruminants. Mouflon group sizes and composition were investigated. Their social organisation was similar to that of other

wild sheep : they formed single-sex groups during most of the year and mixed-sex groups during the rut. However, they were in smaller groups than other wild sheep that live in open habitats. This was thought to be due to the effects of forest dwelling. Males were in smaller groups in the dry season than during the wet season, probably because of the differences in forage availability and dispersion. Food was in large patches in grassy clearings in the wet season and in a more evenly scattered distribution during summer. No significant differences in group size were found between seasons for females. Males were in consistently larger groups than females, which could have been due to a combination of different nutritional requirements of animals of different body size, and to differences in antipredator behaviour patterns between the sexes. Mouflon avoided activity during the hot summer days and foraged in the early morning and in the evening. During winter they fed during most of the hours of daylight.

During the time when the food supply was improving, the daylength was decreasing, which is the stimulus for ovulation in sheep, leading to spring births. In temperate climates births occur as the food supply is increasing, but in the Cyprus mouflon it meant that the young had to cope with reduced quality food soon after they were weaned. However, the males had the opportunity to regain condition after the rut in autumn, whereas ungulates in non-Mediterranean climates are faced with poor quality food from the end of the rut until the following spring.

TABLE OF CONTENTS

FIGURES AND TABLES

APPENDICES

CHAPTER 1
INTRODUCTION

1.1 THE CYPRUS MOUFLON

The Cyprus mouflon *Ovis orientalis* is an endangered sheep found on the island of Cyprus at the eastern end of the Mediterranean. It lives in the forests of the island, and is one of the few forest-dwelling wild sheep. The other wild sheep that live in a forested habitat are the mouflon *Ovis orientalis* of Corsica and Sardinia. There have been few studies of Mediterranean ungulates living in natural habitats. The mouflon of Cyprus offered a good opportunity for studying the ecology of a population of wild sheep in a habitat similar to the original Mediterranean vegetation before it was altered by humans. An additional benefit of using the Cyprus population of mouflon was that they were undisturbed by hunting, this being prohibited by law. They have an autumn rut, and give birth in late March/early April.

The objectives of the study were to investigate the species of plants eaten by the mouflon and to see how this changed in relation to the seasonal changes in plant availability and nutrient quality. An examination of the selectivity of different food plants by mouflon was to be carried out. An investigation of diet quality was also proposed to see how well the animals coped nutritionally with the forest habitat. The grouping behaviour was to be examined to see if it differed from that of other wild sheep found in open habitats, and if it varied seasonally in response to forage changes.

The island of Cyprus has been isolated from the mainland of Europe and Asia Minor for perhaps as much as fifteen million years (Boekschoten and Sondar 1972) There was never a land bridge between the island and the mainland even in the Pleistocene glacial episodes, and the nearest that the mainland ever was to the islands off Cape Andreas (the eastern peninsula of Cyprus) would have been 30km (Swiny 1988). Therefore all non-flying animals had to get to Cyprus either by swimming or rafting, unless imported by humans.

Wild sheep first arose about 2.5 million years ago, and were part of the large mammal fauna that flooded into Europe during the Villafranchian period, presumably from north of the Himalayas. (Geist 1971). The most primitive

extant sheep are urials with 2n=58 chromosomes, with a "bib" of hair under the neck, and with a small patch of light coloured hair around the rump (Geist 1985). Species of *Ovis* with 2n=54 chromosomes probably developed 300,000 years ago (Rutter 1980). These are the mouflons and the pachycerine (American-type) sheep which have very similar karyotypes (Nadler et al. 1974, Korobitsyna et al. 1974). They hybridize with urials on their East flank (Valdez et al. 1978).

Neolithic people arrived on Cyprus around 10,000 years ago (S. Swiny, pers. comm.). With them they brought domestic animals, among which, it is now believed, were wild-type sheep (S. Payne, pers. comm). It is not known whether these were domesticated stock or whether they were wild sheep which were then released into the area as game. Remains of these sheep have been found at Khirokitia, a Neolithic site on the south coast, about 100 miles from the Troodos massif (Fig 1.1) (Davis 1984b). This site belongs to the earliest known period of human presence on the island; the Aceramic Neolithic. The horn cores of these wild sheep, or mouflon, are distinct from those of domestic sheep *Ovis aries*, being more massive and differently shaped (Davis 1984b). Domestic sheep horns are quite small and curl around the ears, while those of Cyprus mouflon curve sideways and backwards. All the Khirokitia horn cores found are wild-type, indicating that they are mouflon (Davis, 1984b). Other bones of sheep are indistinguishable from those of mouflon except for a size difference of +13 to +15% of the metacarpi and metatarsi, but this may be due to genetic bottlenecking (Davis 1984a). Geist (1987) considers the mouflon to be a paedomorphic dwarf, which, although it is derived from urials (Korobitsyna et al 1974), exhibits a sharp reversal to ancestral characteristics. Island dwarfing often occurs in the absence of predators (Azzaroli 1982).

The Pleistocene fossil record from Cyprus, dating from before human arrival on the island, does not include any representatives of animals used by people as domestic stock, but pygmy hippo *Hippopotamus minutus*, pygmy elephant *Elephas cypriotes*, two murid mice species, a shrew *Crocidura russula*, and a genet *Genetta plesistoides* have been found (Davis 1984b) Pygmy hippos are thought to have had similar ecological requirements to pigs, and that if the two had existed sympatrically on the island, one would have disappeared (Davis 1984b). The neolithic fossils at Khirokitia include bones of fallow deer *Dama mesopotamica*, mouflon/sheep, goat *Capra*, pig *Sus*, and fox *Vulpes vulpes*; the wild mammals found on the island today are: mouflon, fox, hare *Lepus capensis*

, hedgehog *Erinaceus auritus*, rat *Rattus rattus*, mouse *Mus musculus*, shrew *Sorex*, spiny mouse *Acomys* and seven species of bat (Davis 1984b). Therefore it appears that with the immigration of humans to Cyprus, along with their domestic stock and accidental introductions, the original wild mammals of Cyprus gradually became extinct.

Evidence for the domestication of sheep from neighbouring countries comes from Israel, where fossils in association with human settlement are found at the beginning of the Chalcolithic, 6000 years ago (Davis 1982b). Sheep are absent from all pre-Neolithic sites in Israel, but appear during the Neolithic suggesting their domestication occurred during the pre-pottery (9000 years ago) or pottery neolithic (7,500-6000 years ago) (Clutton-Brock and Uerpmann 1974). Previous to this, fossils of wild sheep have been found in the Western Negev dating from 10,000-9,000 years ago, which may represent the ancestor of the domestic sheep (Davis et al. 1982).

Today the wild sheep in the areas near Cyprus are found in Turkey, North Iraq and Iran, Punjab (Davis et al. 1982) and Oman (Harrison 1968) and they used to occur in Syria and Israel (Davis 1982). According to Ryder (1987) there were no wool-bearing sheep 8000 years ago, but only those with a wild-type coat such as that of the mouflon. However he states that sheep were penned 11,000 years ago in the Zagros mountains on the border between Iran and Iraq. The oldest wool found so far dates from only 3500 years ago, but figurines have been found from Iran and Sumeria dating from 7000 and 5000 years ago respectively depicting fleeced sheep (Ryder 1987). If the mouflon were brought to Cyprus at least 8000 years ago, they would not, therefore, have been fleece-bearing, but hairy. According to Pfeffer there is no difference between Cyprus and Corsican mouflon (Pfeffer 1967). Corsican mouflon are also thought to have been introduced by people (Ryder 1971, Payne 1968, S. Davis pers. comm.). All Mediterranean mouflon are now considered by Corbett (1984) to be *Ovis orientalis* without sufficient distinction to be a subspecies. The Cyprus wild sheep has been noted by many naturalists and historians; in 1912 Lydekker stated that the Cyprus Red Sheep *Ovis orientalis* lived in the Troodos mountains of Cyprus and in Asia Minor and Persia. The Cyprus mouflon has been hunted since Graeco-Roman times, mosaics depicting it being chased by dogs or cheetah. It used to inhabit both of the forested ranges of Cyprus, which are the Paphos /Troodos and the Northern Range (Anon 1939, Comyn Platt 1938). Much evidence from the Middle ages cites it as being a common

quarry, but later the intensity of hunting reduced the numbers drastically. In 1878 it was found only in the Paphos and Troodos forests, with about 20 animals in the Troodos and 'a few herds' in the Paphos. In 1937 only about 15 animals were said to be left, all in the Paphos forest, so the following year the Cyprus Game Law was amended to protect them. In 1939 the whole of the Paphos forest was declared a Game Reserve, and at the same time goats and their goatherds were excluded. These goatherds had previously ranged through the forest, lighting fires to provide the 'green bite' for their herds, and carrying guns. They also knew the movements of the mouflon (Unwin 1928). With their exclusion, the mouflon were left in relative peace. With no hunting and fewer fires, and also with less competition with goats for food, the mouflon population began to recover. In 1967, Cyprus signed the Form of Acceptance of Ultimate Responsibility for Rare Wildlife Species of the IUCN for this animal. In 1949 the wild population was estimated at about 100 (Waterer 1949); in 1966 at 200 (Red Data Book 1966) and recently at around 800 (A. Iannous pers. comm.) However all these estimates are made by spoor indices or by foresters reports, and it is well known that it is extremely difficult to estimate numbers of woodland mammals by any other method than direct counting and/or individual marking (eg. roe deer in Scottish forests.) However, the animal is still on the endangered species list. In fact, Cassola (1976) regards the Cyprus mouflon as one of the most endangered Mediterranean mouflon races, because of the political turbulence of the island.

1.2 HISTORY OF FORESTS ON CYPRUS

Most of the island of Cyprus was once forested, but the steady removal of trees for firewood, buildings, ships and agriculture over the last few thousand years has resulted in the situation where today the only forests are those growing in the most inaccessible parts of the country, namely the Paphos and Troodos Forests (Dunbar 1983, Wertime 1982). Throughout its history, Cyprus has been a site of strategic importance in the Mediterranean and in consequence has changed hands many times. It has been a Greek, Roman, Ottoman and British-governed island, and is now independent. As a result of an invasion in 1974, the northern 40% of the island is currently occupied by Turkey.

Eratosthenes, a Greek writer of the 3rd century B.C. stated that the plains of

Cyprus had been heavily forested in the past, and that minerals and wood were the two main exports. He also states that the then governors of the island would allow people to clear woodland and keep it as their own property exempt from taxes (Wertime 1982). A huge demand for wood for pyrotechnology fell on the forests during the Bronze and Iron ages, and later in the Roman period, not only for smelting metal-bearing ores but also for the conversion of limestones into cement for waterproofing the cisterns in which water was stored; and for the firing of pottery (Wertime 1982). However, this is most likely to have made use of the Golden Oak, *Quercus alnifolia* and *Pistacia terebinthus*, and carob *Ceratonia siliqua*, all of which coppice well (Dunbar 1983). The destruction of the forest in recent times has been ascribed to extraction of pitch from pine trees, use of the forest for goat-grazing, and by fires which were started by shepherds to encourage the growth of fresh herbaceous fodder plants for their animals (Dunbar 1983, Unwin 1928, Wertime 1982). Therefore the refuge of the forest-dwelling wild animals was gradually reduced to the most remote areas of the island. About 19% of the island is designated as "State Forest Land" (Finlayson 1971) but some is still in the process of being reforested. The Paphos forest comprises 15% of the total forest land (Michaelides 1978) (See Fig 1.1).

1.3 THE PAPHOS FOREST

1.3.1 Geology and soils

The Paphos forest area is on a sheeted intrusive complex, known as the Diabase (Geological Survey of Cyprus 1979), the soils of which are deep red earths, often rapidly eroded if not held by vegetation. Large areas of scree are common on the steeper slopes. On the edges of the area, for instance at Pia and Ayios Mercurios, metabasalts with pillow lava formations are found, which give rise to a brown earth (Soteriades 1961). The Diabase is much harder than the surrounding limestones and has not been eroded to such a degree.

The Paphos forest is roughly circular, with the main valleys radiating out from its centre like the spokes of a wheel (Fig 1.2). This central point is at about 1300m above mean sea level. Because the area has never had the smoothing effect of glaciation, the topography is highly dissected by the action of the hundreds of winter streams that cut deeply into the hills. This has

produced steep slopes, knife-edge ridges and narrow, twisting valleys in the forest, in other words a good refuge for wildlife vunerable to persecution from humans (Fig 1.5). In fact, now that the rest of the island is deforested and under agricultural use, it is the last large forested area left, covering about 60,000 hectares. Patches of scrubby forest remain throughout the island, and reforestation is taking place in many places, but the large mammal fauna is absent from these areas.

1.3.2 Forest type

The main forest trees are *Pinus brutia* and *Quercus alnifolia*. An understorey of *Cistus salviifolius* and *C. creticus* forms a discontinuous cover, and in the wet season many forbs and grasses grow beneath this. The scree covered slopes are more commonly covered by *Q. alnifolia*, those with more soil by *P. brutia*. There are open clearings which are covered by typical *maquis* vegetation (Fig 1.4).

For a more detailed description of the vegetation see Chapter 2.

1.4 THE STUDY AREAS

The areas chosen for investigation were as follows:

1. Ayia. This is a steep-sided valley covered with *Pinus brutia* dominated forest. It runs south-west from the centre of the Paphos forest. The altitude of the area investigated was between 600-800 above sea level.

2. Vroisha area and Fleyia valley. Henceforth referred to as Vroisha. Similar in topography to Ayia, but running north-west from the centre. Much of it is forested, but there is an abandoned village site at Vroisha with some grassy terraces. Altitude 600-700m. a.s.l.

3. Pia. An area near the western border of the Paphos forest. Less mountainous that the first two areas, and less densely forested. The habitat is more open, with scrub, pines, and grassy clearings. The altitude is 400-500m. a.s.l.

4. Limnitis. This valley is similar to Fleyia valley in topography, and runs parallel to it. However the mature forest was burned in the forest fires of 1974

and the area has been replanted. Thus the habitat consists of small pine trees and a flourishing maquis ground layer. The altitude is 500-800m. a.s.l.

5. Ayios Mercurios. This is an area in the west of the Paphos forest, less mountainous than Ayia, Vroisha or Limnitis. The valley runs westward. There are areas of mature pines and clearings. Altitude is 400-500m. a.s.l.

The first three valleys were sampled for vegetation and for mouflon faeces all year round, but Ayios Mercurios and Limnitis were abandoned after the first summer due to the difficulties of travelling there.

1.5 CLIMATE

Cyprus has a Mediterranean climate, with hot dry summers and cool wet winters. Fig. 1.3 shows the rainfall and temperature pattern in Trikkoukia, a site to the east of the Paphos Forest, at 1200m. Temperatures in the study areas at lower elevations would have been somewhat higher than at Trikkoukia, but the yearly pattern can be seen. In general, rainfall is low, usually less than 400mm on the southern edge of the forest, a little greater on northern slopes, and increases with altitude. It does not exceed 900mm on the Troodos (Quezel 1979). The seasons, where mentioned in the text, were defined as follows: Spring= March, April, May; summer= June, July, August and September; autumn= October and November, and winter=December, January, February.

Fig. 1.1. Map of Cyprus showing the Paphos Forest (shown in black) and the Troodos mountains. Inset is a small map showing the location of Cyprus.

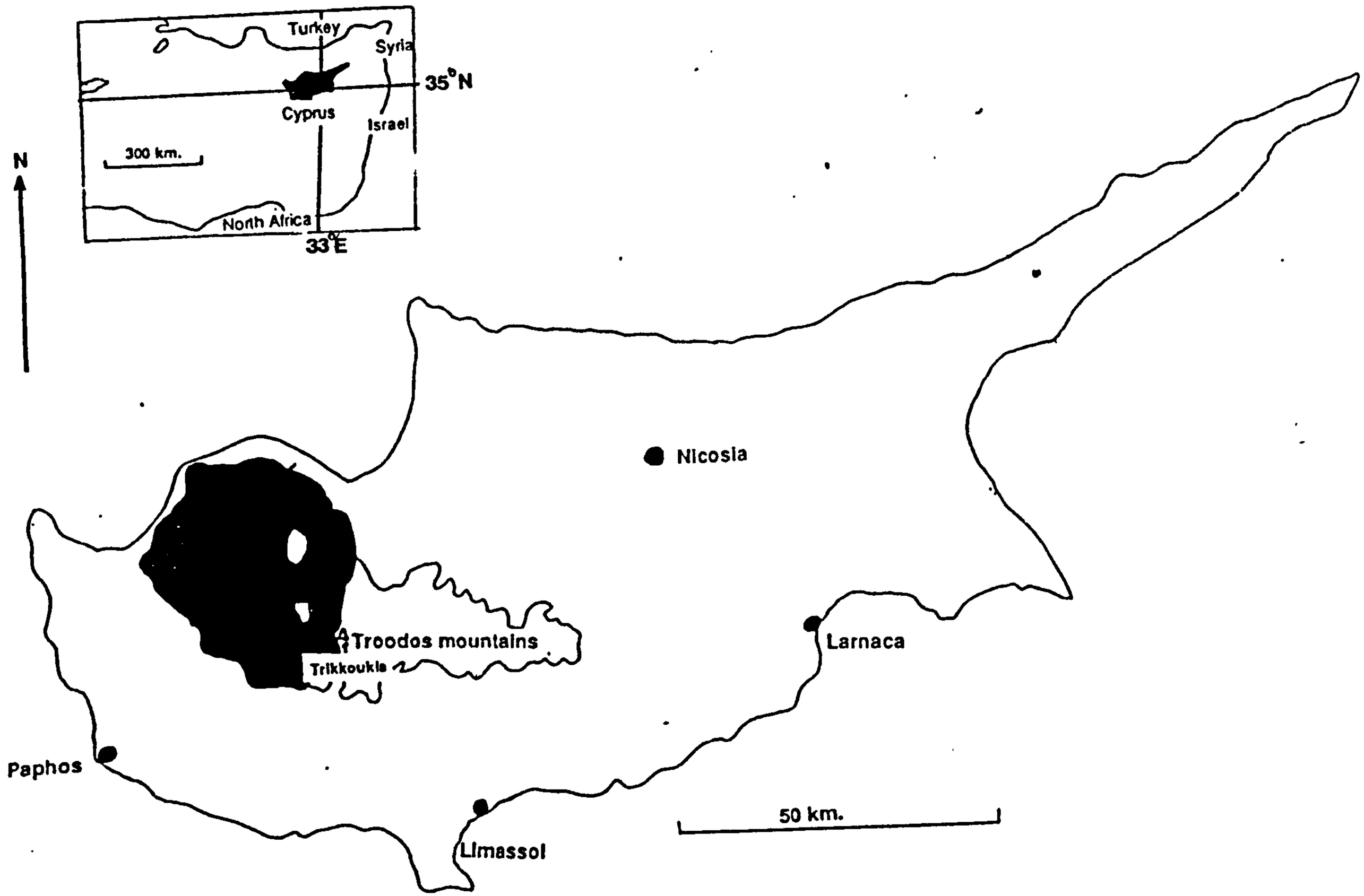


Fig 1.2

Map of the Paphos forest, showing main valleys and placenames.

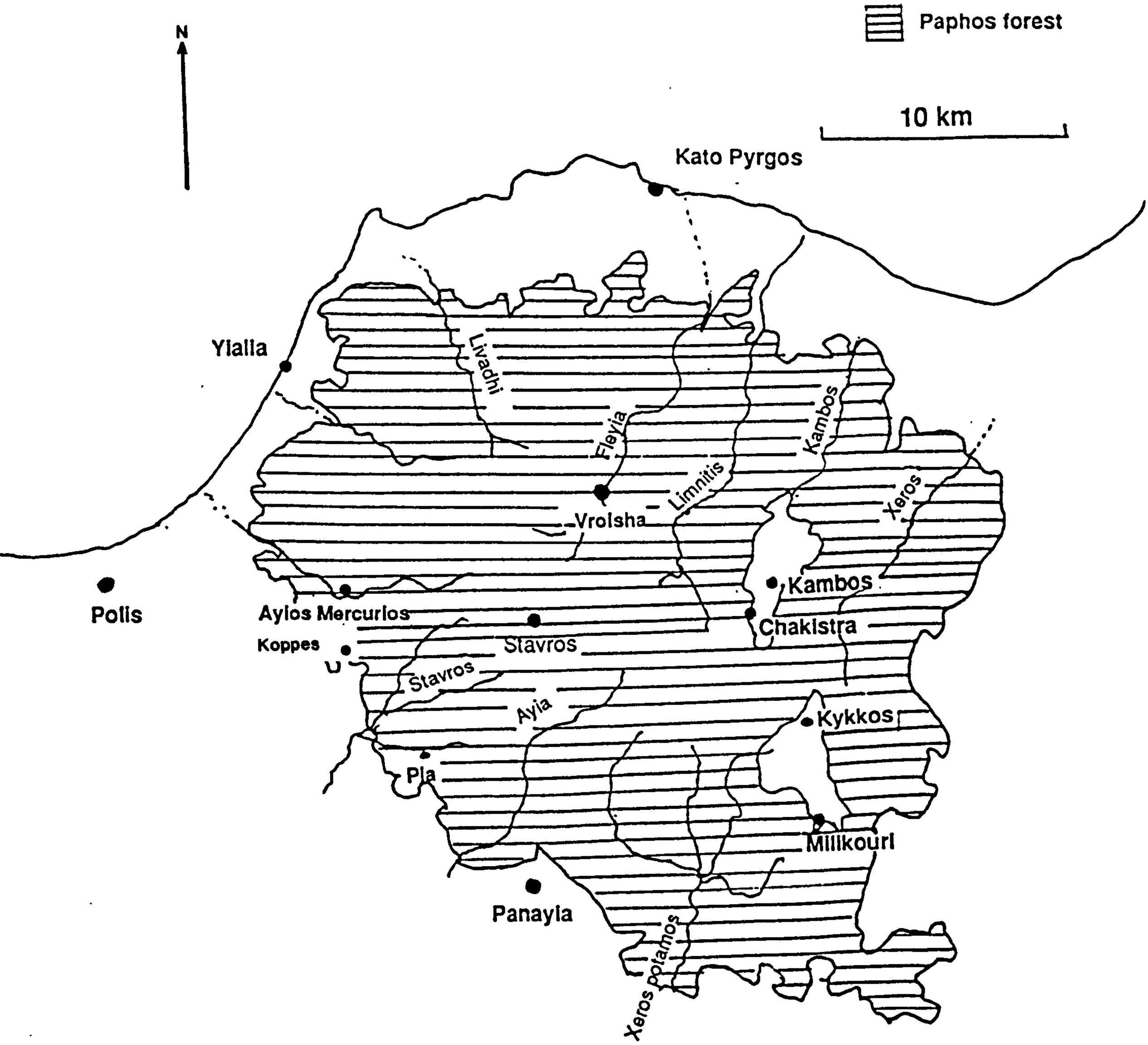


Fig 1.3

Mean monthly rainfall and temperature (maximum and minimum) at Trikkoukia, at 1200m in the Troodos mountains.

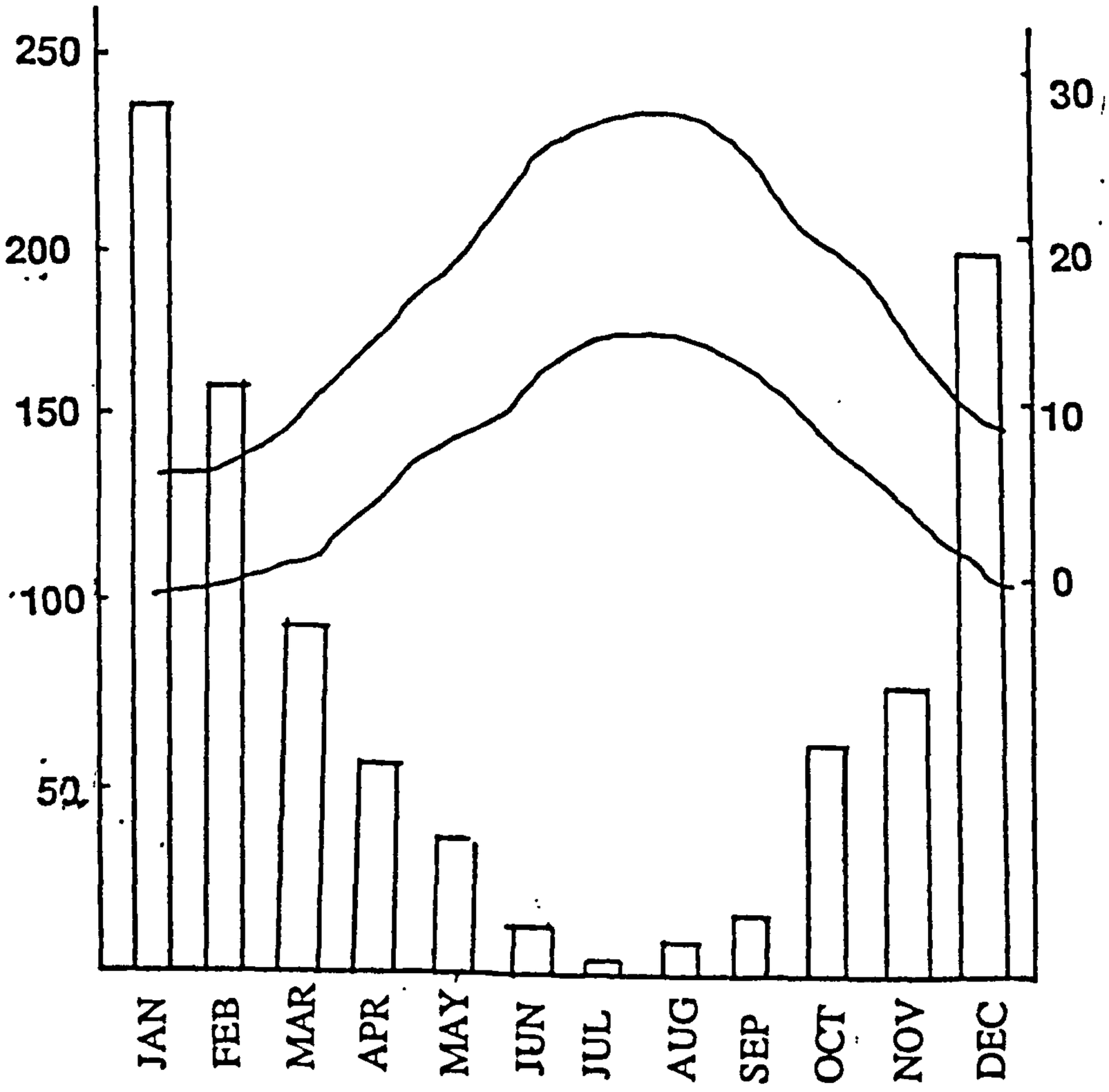


Fig. 1.4 An area of open habitat, showing the maquis vegetation. The large monocotyledons are *Urginea maritima*.

Fig. 1.5 A typical valley in the Paphos Forest, forested mainly with *Pinus brutia*, with understorey of *Cistus* spp. The terracing on the left hand side is a patch of reforestation.

Fig. 1.6 A male mouflon in winter coat.

Fig. 1.7
A group of mouflon in October. The males have horns, the females are hornless.

CHAPTER 2
VEGETATION SURVEY AND FOOD AVAILABILITY

2.1 INTRODUCTION

To investigate the importance of different foods to the mouflon, it was first necessary to estimate the abundance of each food plant in the environment. The results could then be compared with those of the diet analysis to obtain a measure of how selective the animals were of the food plants (Chapter 6). As Cyprus is a highly seasonal environment, it would be expected that the availability of annual and deciduous plants would change drastically throughout the year. A general description of the habitat could also be obtained from this data. Little quantitative work has been done on mountain forest flora from the Mediterranean, especially in Cyprus.

2.2 METHODS

The method chosen for vegetation analysis had to be appropriate for estimating availability of different plants to the mouflon, and it had to be efficient in estimating percent cover of different species without the need for counting individual plants, which is very time consuming. Cover was defined as the proportion of the ground occupied by perpendicular projection on to it of the aerial parts of individuals of each species under consideration (Greig-Smith 1957). In other words, it was an estimation of the area covered by each species expressed as a percentage of the total area and estimated from a number of sample points. This visual estimation is subject to personal bias between observers, but as there was only one observer present and relative frequencies of plant cover were being measured, this factor was not considered an important one. At the beginning of the study period, in April 1984, plots 20m X 20m were chosen at random throughout the study area and marked with a stick at each corner. Ten 1m X 1m quadrats were then chosen at random within each plot and the centre of each quadrat was marked with a small stick. The plots were visited at intervals throughout the study period. Each time, the same quadrats were scored for plant cover. The quadrat was aligned with the sides of the plot and centred on the marker stick on each visit in order to ensure that the same area was being re-scored each time. The percent cover

of each species of plant was estimated by eye for each quadrat and the results recorded. It was often the case that the total ground cover estimated was above 100%. This is usual in all but the most open plant communities when a percent cover method is used (Greig-Smith 1957) and it also provides an idea of the structure of the vegetation. For instance, 200% cover may occur when the ground layer (grass for instance) is completely overshadowed with a shrub). Because mouflon cannot reach high vegetation by stretching, or by climbing into bushes, vegetation cover above 1.3m was considered unavailable to the animals and not included in the samples. The figure of 1.3m was arrived at by measuring the height above ground of 10 browsed twigs of *Prunus dulcis* (apricot) and none of these came above 1.3m. Although many plants were senescent or dead in the dry season, their percent cover was still recorded. Herbivores will eat leaf litter if there is not sufficient live material available, and recording the amount of the leaf litter ensured that a possible food resource was not omitted from the data.

2.3 RESULTS

2.3.1 Habitat

The data collected from the quadrats (Appendix 1) was used as follows. For a basic description of the habitat, plant species were allocated to one of four categories: Trees, Grass, Ephemerals and Shrubs (see Appendix 2) and the amount of bare ground included. The results were expressed as percent cover and are shown in Table 2.1. The valleys were then compared in terms of general habitat type. These results are presented graphically in Fig 2.1. From Fig. 2.1 it can be seen that Pia valley had a more pronounced fluctuation in ground cover than the other two valleys for which year-round data was available (Vroisha and Ayia). The amount of bare ground in Pia varied between 10-65% during the course of the year, whereas that in Vroisha ranged between 25-60% and in Ayia between 50-75%. Ayia showed the least annual variation in ground cover. Those plants which are most likely to dry up and disappear (the grasses and ephemerals) were certainly at their lowest in terms of ground cover during the late summer and early autumn, but the magnitude of difference was much less than in Vroisha, and very much less than in Pia. In Vroisha and in Pia grasses and ephemerals comprised 50-60% of the ground cover during the winter months; and only 10-40% during the late summer.

Unsurprisingly, tree cover did not vary a great deal between seasons in any valley.

2.3.2 Food availability

The availability of each species was calculated by month and valley using the botanical survey data. The means of the plant cover per plot were used as the basic data set (Appendix 1). This data was then used for a description of food types as they are available to mouflon. 'Bare Ground' was removed from the dataset and only actual plant cover was considered. Because only seventeen categories of epidermal fragments could be easily distinguished from the reference collection, (see Chapter 4), the plant species were this time allocated to these categories (Appendix 2). This data is presented in Table 2.2. Then the data for each plant type was expressed as a percentage of the total ground cover by month in each valley (Fig 2.2). This was done so the data on plant availability could be compared with the data from the faeces analysis to find out the selectivity index of each food type (see Chapter 6).

The plant categories used are presented later, in Table 4.1. The reason that *Pistacia terebinthus* and *Trifolium clypeatum* were in a single category was that they were indistinguishable from each other in their epidermal characteristics. Therefore when mouflon faeces were examined to discover what plant types were consumed, (see Chapter 4), these species were scored as a single category.

The proportion of forbs available was fairly high throughout the year, although there was less available during the dry season especially during September and October. *Cistus* spp. were common in all valleys. Some shrubs were rare in some valleys: *Lithodora* was only common in Vroisha; *Teucrium* in Ayia and Vroisha. Broadleaved trees did not appear common in any valley except Ayia; but their availability may have actually been somewhat higher than indicated in the data collected from the botanical survey. The quadrat method used underestimated the available overhanging branches of mature trees, although attempts were made to include these when recording. Some of these branches could, if hanging below 1.3m, be reached by mouflon. In general, the main plants available were *Cistus* spp, forbs, grasses, and in some valleys but not in others, broadleaved trees, *Asphodelus*, *Rubus* and *Quercus alnifolia*. Although the forest is dominated by pine trees, most of them were too tall for

their branches to be within reach in the quadrats sampled, so their availability is fairly low.

TABLE 2.1

Percent cover of trees, grasses, shrubs, ephemerals, and bare ground in the valleys of Ayia, Pia, Vroisha.
For a list of the species in each type see Appendix 2.

Ayia

MONTH	Grass	Bare ground	Ephemeral	Shrubs	Trees
JAN	7.8	65.5	6.9	13.7	10.6
FEB	8.9	65.8	8.9	13.2	10.1
MAR	9.6	56.6	11.2	13.5	9.0
APR	8.5	52.6	16.8	16.7	8.9
MAY	4.8	58.2	14.3	19.0	6.6
JUN	6.7	58.7	11.2	14.5	14.8
JUL	2.9	63.6	9.6	13.9	13.8
AUG	0.9	56.9	7.0	18.9	16.2
SEP	2.4	74.7	7.4	13.2	4.7
OCT	0.3	66.6	36	18.7	11.0
NOV	6.7	64.2	7.0	15.9	9.3
DEC	5.9	64.3	8.8	12.6	11.2

Pia

	Grass	Bare ground	Ephemerals	Shrubs	Trees
JAN	36.4	8.2	29.0	24.3	2.4
FEB	34.8	8.6	30.0	24.8	2.8
MAR	32.9	8.7	31.1	25.1	3.5
APR	24.3	13.9	32.2	27.5	3.6
MAY	15.5	47.3	11.4	22.04	4.8
JUN	17.6	46.6	13.0	19.4	3.8
JUL	-	-	-	-	-
AUG	7.4	64.6	5.7	17.5	7.1
SEP	34.1	33.4	8.5	21.3	3.8
OCT	27.5	32.1	14.0	23.9	3.1
NOV	33.3	15.1	24.3	24.4	3.6
DEC	36.5	7.2	29.2	24.6	3.0

Vroisha

	Grass	Bare ground	Ephemeral	Shrubs	Trees
JAN	14.4	32.8	38.7	18.2	5.7
FEB	16.0	29.9	36.3	17.3	5.5
MAR	14.4	34.2	34.7	17.6	3.4
APR	23.3	26.8	37.0	15.9	4.6
MAY	10.2	47.2	27.1	13.1	4.5
JUN	15.9	55.9	12.8	16.6	4.9
JUL	11.4	41.6	27.8	21.9	6.5
AUG	-	-	-	-	-
SEP	20.4	61.1	10.6	8.1	6.2
OCT	18.5	53.4	12.6	21.6	5.0
NOV	23.9	28.9	29.7	20.6	5.5
DEC	14.2	38.4	28.3	21.9	5.9

TABLE 2.1

Percent cover of trees, grasses, shrubs, ephemerals, and bare ground in the valleys of Ayios Mercurios and Limnitis.
For a list of the species in each type see Appendix 2.

Ayios Mercurios

	Grass	Bare ground	Ephemeral	Shrubs	Trees
JAN	-	-	-	-	-
FEB	-	-	-	-	-
MAR	-	-	-	-	-
APR	-	-	-	-	-
MAY	42.5	25.0	28.9	11.8	3.2
JUN	37.6	48.1	5.2	17.3	2.7
JUL	51.6	20.4	23.5	0	4.5
AUG	-	-	-	-	-
SEP	42.0	49.2	6.9	19.3	2.7
OCT	-	-	-	-	-
NOV	-	-	-	-	-
DEC	-	-	-	-	-

Limnitis

MONTH	Grass	Bare Ground	Ephemeral	Shrubs	Trees
JAN	-	-	-	-	-
FEB	-	-	-	-	-
MAR	-	-	-	-	-
APR	-	-	-	-	-
MAY	9.3	28.6	33.1	24.4	7.3
JUN	9.1	376	25.4	21.1	8.3
JUL	-	-	-	-	-
AUG	15.8	47.8	14.3	17.9	9.7
SEP	-	-	-	-	-
OCT	-	-	-	-	-
NOV	-	-	-	-	-
DEC	-	-	-	-	-

TABLE 2.2

Percent cover of epidermally recognised plant types in the valleys of Ayia, Pia, Vroisha, Ayios Mercurios and Limnitis.

For a list of the species in each type see Appendix 2. Epidermally recognised denotes that each type was distinct when the epidermiswas examined at 100x magnification.

Ayia

	Astragalus	Asphodelus	Broadleaves	Cistus spp.	Forbs	Grasses	Lithodora	Monocots	Pinus brutia	Quercus a.	Rubus sanctus	Styrax	Teucrium	Pistacia
JAN	0	6.38	27.45	25.41	19.18	19.31	0	3.78	0	12.97	12.81	0	4.26	1.03
FEB	0	7.19	29.38	32.46	18.42	16.04	0	4.71	0	16.87	11.92	0	4.38	2.02
MAR	0	10.0	28.76	26.13	24.67	19.25	0	3.10	0	8.89	8.82	0	3.86	0
APR	0.86	7.91	16.92	29.06	36.30	12.71	0	3.11	0	8.71	7.77	2.79	2.07	1.67
MAY	1.59	4.27	10.40	41.59	39.16	12.32	0	1.96	0.21	4.52	9.21	0.87	0.77	1.75
JUN	0.34	5.62	23.40	28.96	28.77	13.23	10.20	1.77	0	17.95	7.93	1.71	2.18	10.61
JUL	0.29	5.47	20.24	35.03	26.78	8.07	11.47	1.54	0	21.49	14.66	0.57	0.70	13.31
AUG	0	21.65	27.81	37.86	9.03	2.02	0	1.50	0	14.95	0.88	0	3.03	0
SEP	0.83	0	10.83	57.92	28.89	13.09	0	2.35	0	3.22	15.78	0.79	1.41	7.88
OCT	1.81	15.79	22.33	44.45	9.67	1.33	0	1.14	0	20.32	5.81	2.54	3.95	0.42
NOV	1.57	2.99	21.42	41.78	23.62	13.39	0	1.93	0	11.57	9.36	1.88	3.71	3.59
DEC	0	4.50	30.86	28.36	22.57	16.11	0	2.18	0	13.71	15.51	0	4.46	2.96

Pia

	Astragalus	Asphodelus	Broadleaves	Cistus spp.	Forbs	Grasses	Lithodora	Monocots	Pinus brutia	Teucrium	Pistacia
JAN	2.28	1.08	3.74	23.03	36.79	39.92	1.14	1.75	2.12	0	0
FEB	2.31	1.13	3.08	23.61	36.40	38.09	2.32	1.25	1.53	0	0
MAR	2.41	2.01	4.42	23.61	39.80	36.01	2.53	0.68	1.97	0	0
APR	1.74	1.99	4.11	24.13	47.80	28.63	2.31	1.13	2.06	0	0
MAY	0.90	3.79	6.63	32.40	39.97	26.96	0.75	1.27	5.42	1.38	3.40
JUN	0.13	4.48	9.49	20.38	38.70	33.23	2.43	3.35	4.34	1.28	12.52
JUL	-	-	-	-	-	-	-	-	-	-	-
AUG	0.23	2.18	12.63	26.40	37.78	22.33	4.88	4.56	6.65	0.74	18.69
SEP	0.70	2.09	6.09	28.80	25.83	49.89	1.39	2.42	4.27	0	0
OCT	3.24	1.11	7.17	31.83	28.44	40.20	1.62	2.05	3.96	0	0
NOV	1.85	0.29	5.75	25.79	35.26	39.24	1.85	1.28	3.47	0	0
DEC	2.28	0.64	2.85	23.14	36.70	39.64	1.42	1.90	2.69	0	0

Table 2.2 **Percent cover of each plant type over the year.** For a list of the plant species in each category see Appendix 2.

Vroisha

	Astragalus	Asphodelus	Broadleaves	Cistus spp.	Forbs	Grasses	Lithodora	Monocots	Pinus brutia	Quercus	Rubus sanctus	Styrax	Teucrium	Pistacia
JAN	0	4.58	0	18.38	51.81	18.42	12.12	2.98	5.34	54.27	27.31	0	3.58	0
FEB	0	5.66	0	17.72	48.96	19.99	7.31	3.00	4.23	55.71	8.84	0	4.35	0
MAR	0	5.42	0	24.71	44.52	17.54	5.83	3.18	1.31	45.66	26.45	0	5.71	0.29
APR	0.91	5.89	2.52	18.38	44.15	24.46	4.94	5.49	3.05	41.29	28.62	0	6.45	2.52
MAY	0.98	3.83	7.45	22.66	51.74	14.53	5.97	1.48	3.08	44.57	26.44	0.79	6.71	2.56
JUN	0	4.63	7.67	28.03	36.35	28.56	11.33	1.17	6.26	62.43	17.20	0	4.33	0.83
JUL	0	6.25	0	26.18	36.75	12.90	9.26	2.45	0.30	58.10	36.78	0	7.03	3.95
AUG	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SEP	0	8.34	10.00	24.64	29.36	37.95	5.22	2.46	11.19	65.67	0	0	3.58	5.61
OCT	0	4.75	16.43	35.24	32.11	30.01	9.17	0.79	2.92	38.53	39.02	0	6.49	1.08
NOV	0	1.17	2.49	27.16	39.15	25.07	8.65	2.67	3.52	55.89	37.69	0	4.85	0
DEC	0	3.90	0.30	25.60	41.93	21.15	9.16	2.59	3.73	53.14	33.75	0	5.04	0

Ayios Mercurios

	Astragalus	Asphodelus	Broadleaves	Cistus spp.	Forbs	Grasses	Monocots	Pinus brutia	Rubus sanctus	Pistacia
JAN	-	-	-	-	-	-	-	-	-	-
FEB	-	-	-	-	-	-	-	-	-	-
MAR	-	-	-	-	-	-	-	-	-	-
APR	-	-	-	-	-	-	-	-	-	-
MAY	3.10	0	1.57	37.13	31.36	42.92	16.53	3.14	11.58	1.31
JUN	4.10	0.16	1.78	41.91	10.28	64.20	3.15	2.97	16.79	3.28
JUL	0	0	1.88	0	29.00	64.82	0	3.77	0	0.25
AUG	-	-	-	-	-	-	-	-	-	-
SEP	4.80	0	2.07	50.82	17.56	48.83	1.62	5.33	16.59	1.22
OCT	-	-	-	-	-	-	-	-	-	-
NOV	-	-	-	-	-	-	-	-	-	-
DEC	-	-	-	-	-	-	-	-	-	-

Table 2.2

Limnitis

	Asphodelus	Broadleaves	Cedrus libani	Cistus spp.	Forbs	Grasses	Monocots	Pinus brutia	Quercus	Teucrium	Pistacia
JAN	.	.	.	.	.	.	.	.	.	.	.
FEB	.	.	.	.	.	.	.	.	.	.	.
MAR	.	.	.	.	.	.	.	.	.	.	.
APR	.	.	.	.	.	.	.	.	.	.	.
MAY	4.72	0.60	0.50	37.39	46.62	10.97	0.86	4.49	24.76	0	1.55
JUN	5.86	0.47	0.51	37.62	37.55	12.38	0.65	3.40	53.38	5.68	2.25
JUL	.	.	.	.	.	.	.	.	.	.	.
AUG	6.35	0	0.94	39.39	25.90	25.06	0.80	7.71	32.15	0	8.46
SEP	.	.	.	.	.	.	.	.	.	.	.
OCT	.	.	.	.	.	.	.	.	.	.	.
NOV	.	.	.	.	.	.	.	.	.	.	.
DEC	.	.	.	.	.	.	.	.	.	.	.

Fig 2.1

Percent ground cover in the different valleys throught the year.

Bare=bare earth; Tree=all coniferous and broadleaved trees; Shrub=all woody plants not in the tree category; Ephem=all non-graminaceous monocotyledons plus all forbs; Grass=all grass species. Some months add up to more than 100% because shrubs overshadow the ground flora. No data=*

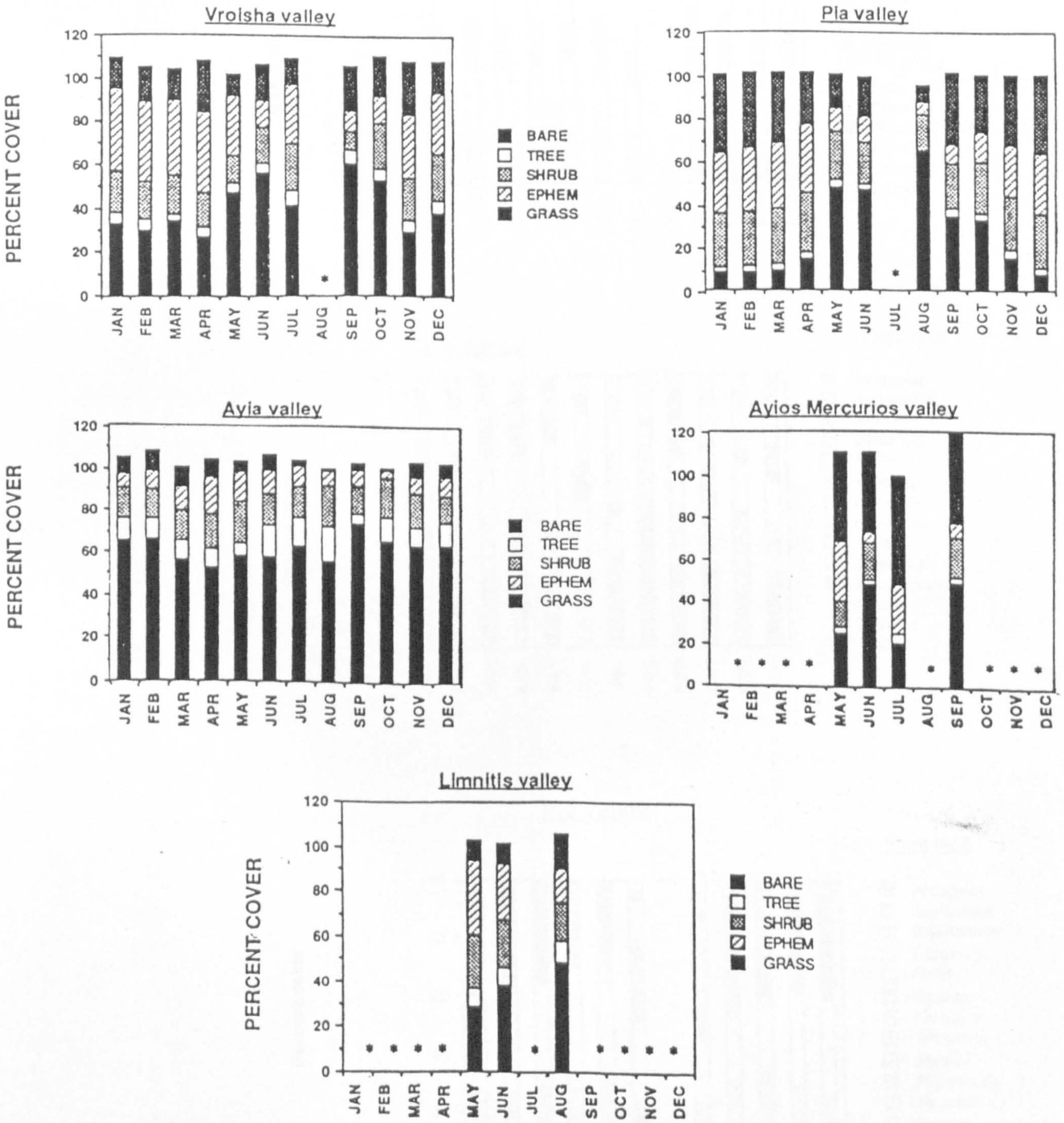
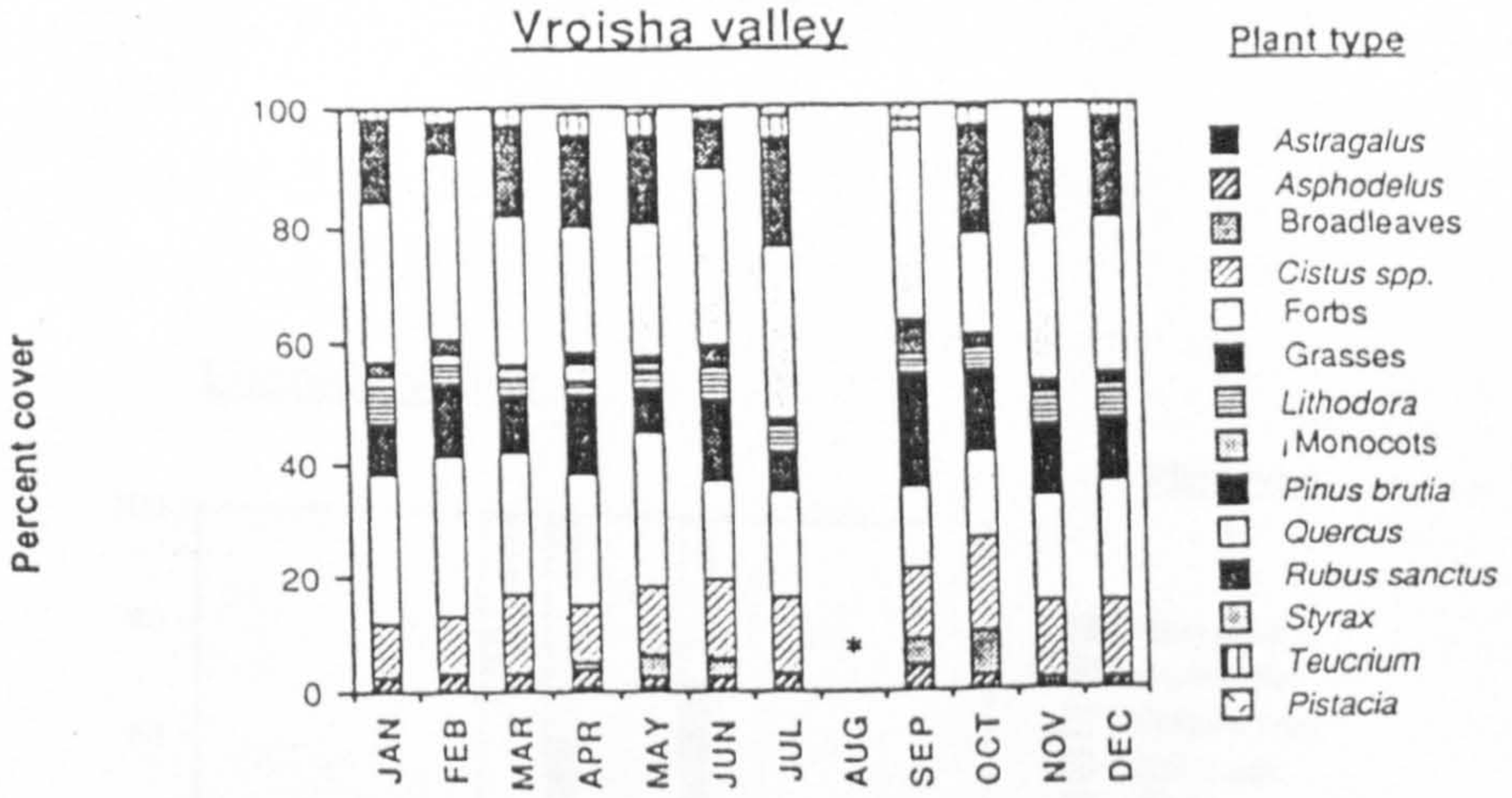
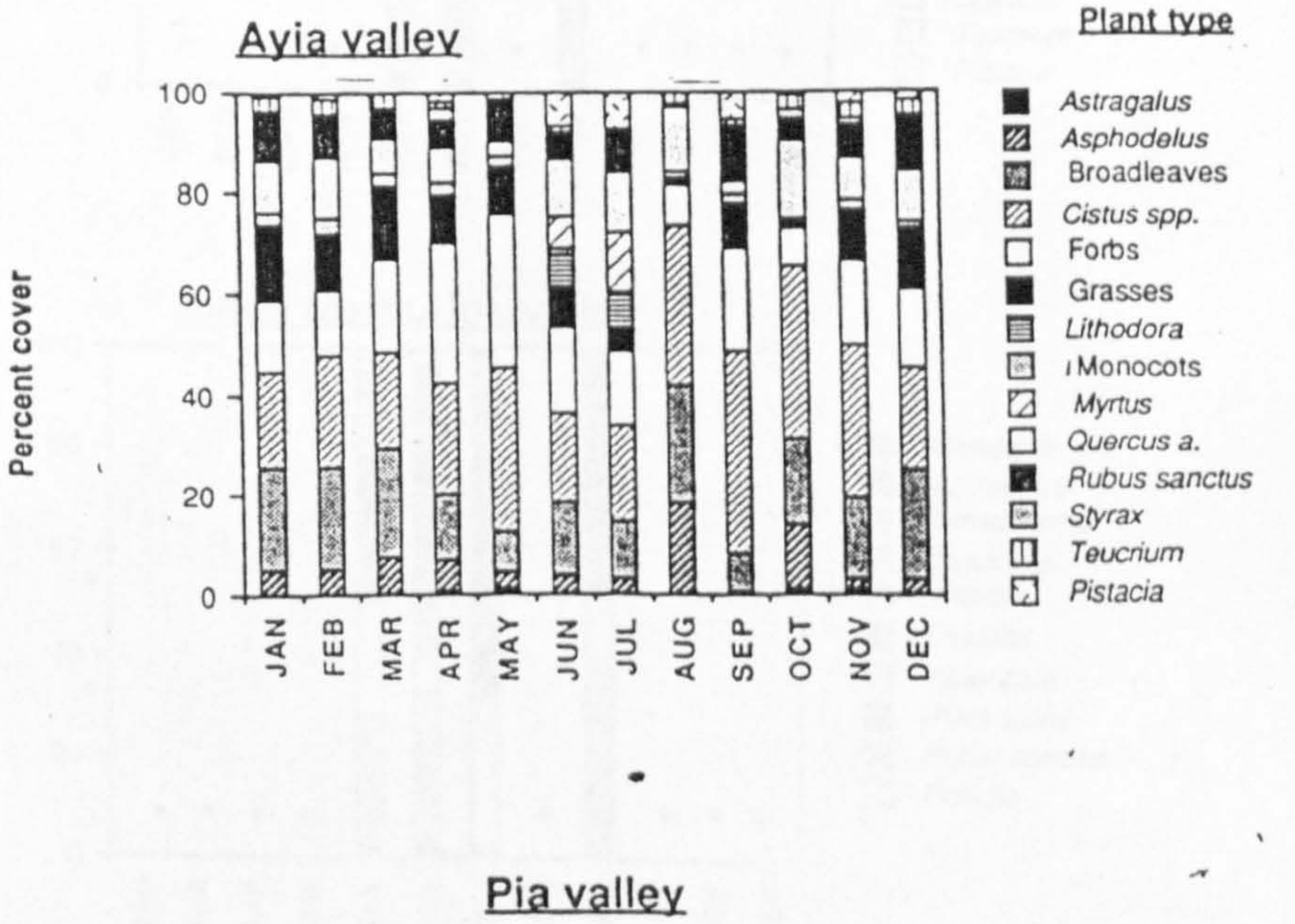


Fig 2.2

Percent cover of epidermally recognised plant types in the valleys of Ayia, Pia, Vroisha .

For a list of the species in each type see Appendix 2. Epidermally recognised denotes that each typ was distinct when the epidermis was examined at 100x magnification.





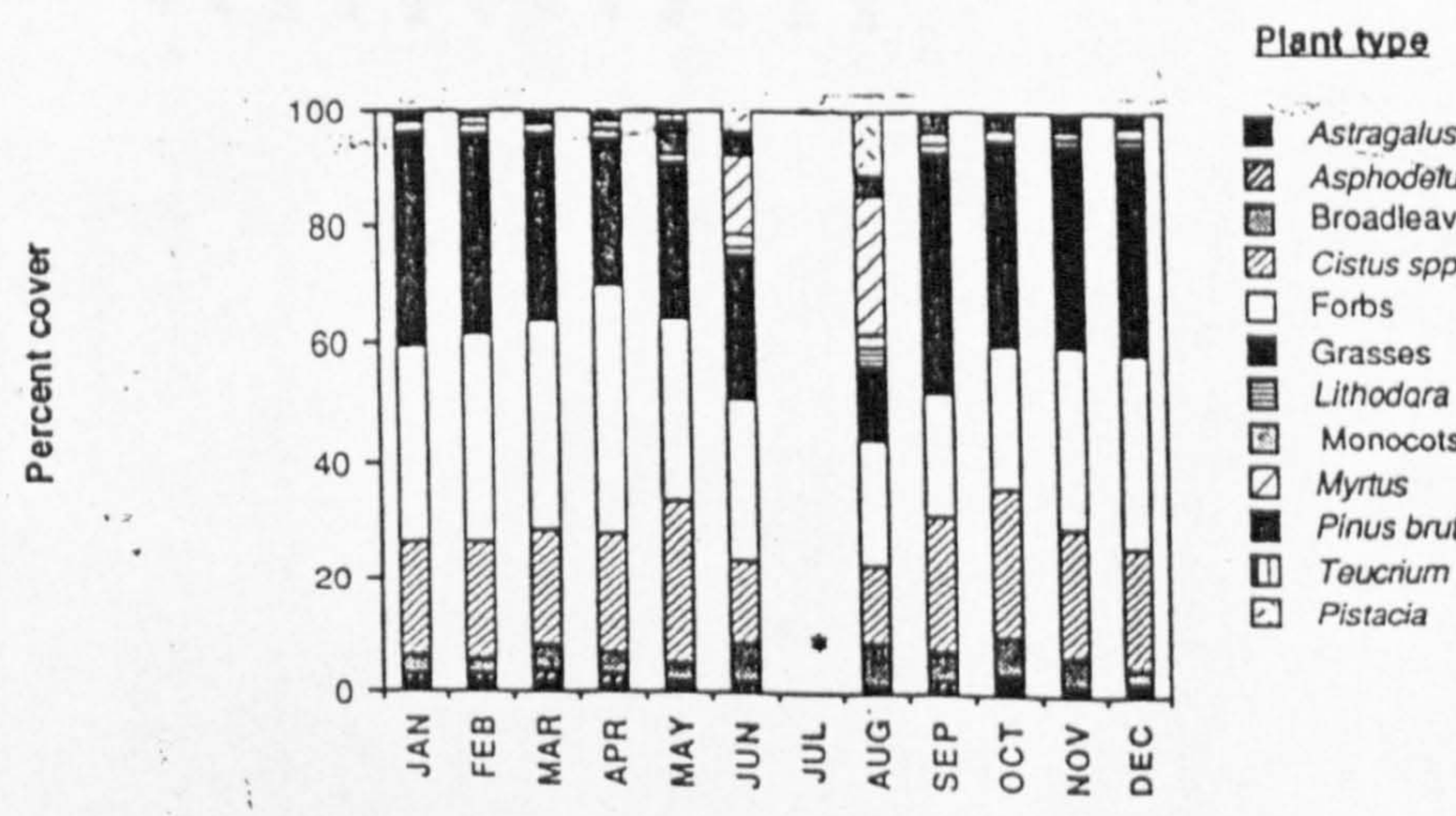
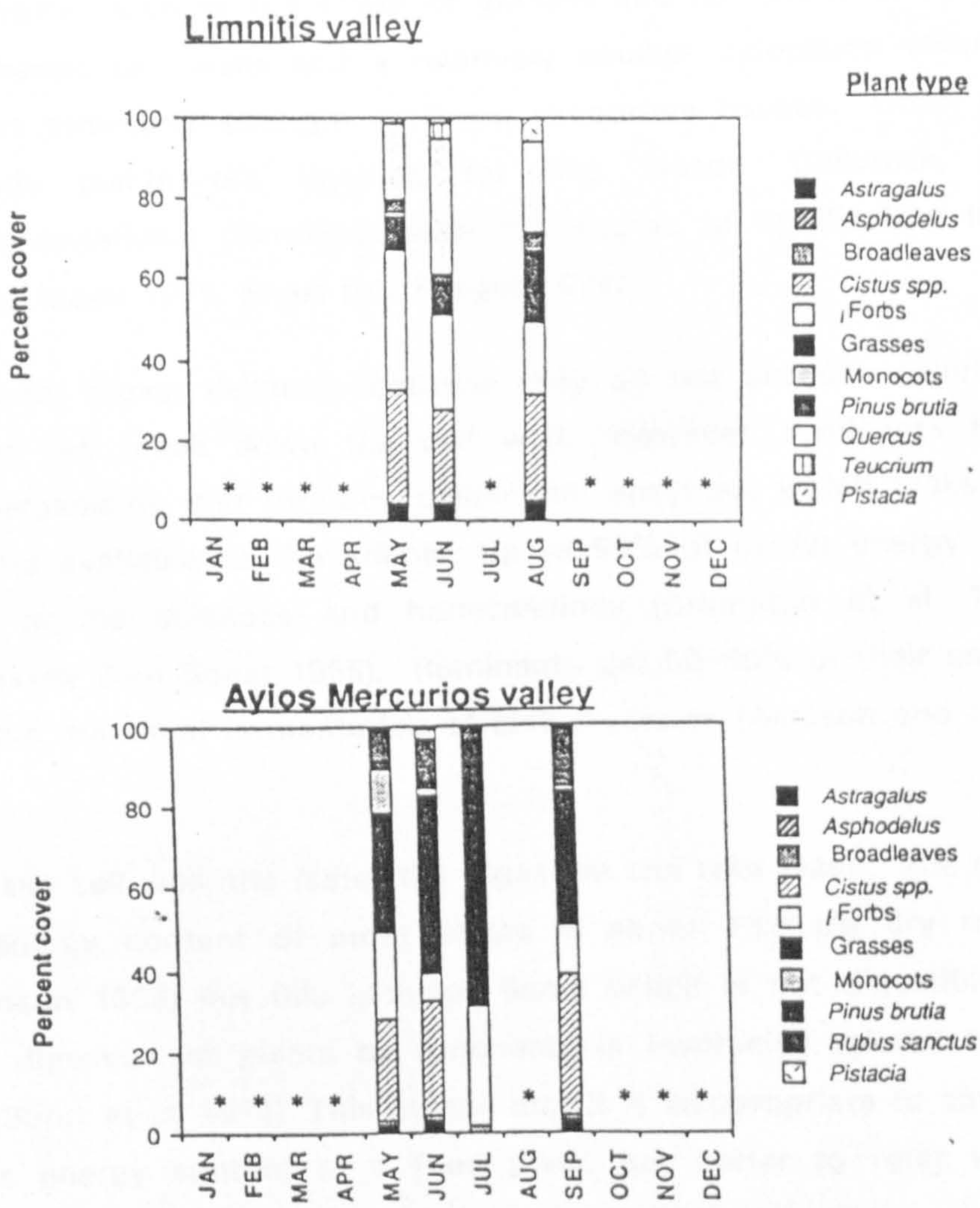


Fig 2.2

Percent cover of epidermally recognised plant types in the valleys of **Ayios Mercurios and Limnitis.**

For a list of the species in each type see Appendix 2. Epidermally recognised denotes that each type is distinct when the epidermis is examined at 100x magnification.



CHAPTER 3
FOOD QUALITY

3.1 INTRODUCTION

The nutritional value of plant matter to herbivores is related to its digestibility and to its digestible protein content. The cytoplasm of plant cells contains protein and soluble carbohydrates. Plant cell walls are made of cellulose and sometimes include lignin and hemicellulose. Leaves and fruits of grasses have thin cell walls, and so do young tissues of most other plants. Older tissues however, such as the stalks of grasses and the stems of woody plants, have thickened cell walls and a relatively smaller cytoplasm volume. Thickening confers structural strength to these supportive tissues. Often the tissues of woody plants are lignified for this reason. Cellulose and hemicellulose are negatively correlated with the degree of lignification in a plant (Robbins and Moen 1975, Short and Reagor 1970).

Mammals cannot digest cellulose because they do not produce cellulase, the enzyme that can break down the cell wall. However, ruminants have symbiotic microorganisms that produce cellulolytic enzymes, which make the cellulose in plants available to the animal. Up to 50% of useful energy of a forage may be in the cellulose and hemicellulose (Crampton et al. 1960) especially in grasses (Van Soest 1965). Ruminants get 50-60% of their energy requirements from microbial fermentation of carbohydrates (Annison and Lewis 1959).

The thinner the cell wall, the faster the digestion can take place. The gross (combustible) energy content of most plants is about 18.8kJ/g dry matter (Garrett & Johnson 1983) but this includes lignin which is not digestible. In fact, extent of digestion of plants by ruminants is inverseley related to the lignin content (Short et al. 1974). This means that it is inappropriate to speak in terms of gross energy content of a food plant, but better to refer to the percent of digestible energy within the plant. Methods for evaluating digestibility of forage include *in vivo* trials, where animals are fed known amounts of material and the amount of excretory products measured. These are urine, faeces, and gases (gases are estimated indirectly). *In vitro* digestibility trials have been developed to reduce the time and cost of

estimating forage digestibility, especially in cases where the ruminants are wild animals and not available for confinement in the conditions necessary for *in vivo* trials. Predictions from *in vitro* trials are very close to *in vivo* values (Belovsky and Jordan 1978, Donefer et al. 1960, Drozdz 1979, Palmer and Cowan 1980, Robbins and Moen 1975, Van Soest 1982).

Sheep are considered to be grass-preferring intermediate feeders (Pfister and Malechek 1986, Robbins et al. 1987b). Mouflon living in the Paphos forest have conifers, broadleaved trees, several shrub species, grasses, other monocotyledonous herbaceous plants, and forbs from which to select their food. Nutrient analysis of these plant species would indicate their potential food values to the mouflon at different times of year. It has been suggested that, in times of poor forage quality, dietary protein deficiency could be more deleterious than energy deficiency because prolonged negative protein balance leads to loss of muscle mass and to decreased resistance to disease (Harper et al. 1977, Robinson 1977, Swick and Benevenga 1977). Catabolism of fat leads only to weight loss. Therefore an idea of which plants contain sufficient protein to maintain a sheep would be useful in understanding mouflons' diet choice in the hot, dry, Mediterranean summer, when many plants are senescent or dead. Because the ingestion of protein-rich foods can improve the digestibility of otherwise poorly digestible plants (Hobbs et al. 1981, McCullough 1979) it is also useful to know if there are any plants with high protein levels available when the rest of the vegetation is at its lowest ebb, and in general poorly digestible, and, if so, which plants these were.

The minimum levels for sheep maintainance are: 5-7% for crude protein (Agric. Res. Council 1965, Mould and Robbins 1981, Robbins et al. 1975); 0.5% for potassium (NRC 1975); 0.25% for phosphorus (NRC 1975) and 50% for digestibility. This last figure is that below which the ruminant cannot maintain itself (Amman et al. 1973). Squires (1980) calculated that, for sheep, the energy required to digest a diet equalled the energy content of that diet when digestibility was 50%. Therefore it would be expected that mouflon, where possible, would select plants that were above these minima especially if they were not very rare or inaccessible species. The objectives of this section of the work were to investigate which plants contained sufficient nutrients to be acceptable to the mouflon, and how this varied with season.

3.2 METHODS

Plant parts were collected throughout the study period for later analysis. Collections were made in April, June, August and October in 1984; in April, June, October and November in 1985, and in January, February and April in 1986. Each sample was composed of parts taken from several separate individuals of a species, to minimise the effect of individual variation. The sample was then placed in an airtight bag and frozen for storage. Each sample was later weighed to the nearest 0.01g, dried in an oven at 80°C for 24 hours, and reweighed to find moisture content. They were then resealed in airtight bags. The samples were then taken to Edinburgh and ground through a 0.5mm screen in a Retsch centrifugal mill.

3.2.1 Digestibility

The *in vitro* digestibility of food items provides the best practical evaluation of a grazing animals diet because it indicates the portion that can actually be used in the animals body (Van Soest 1982). The standard technique of artificial rumen procedure is that of Tilley and Terry (1963). The main disadvantage of the Tilley and Terry method is the length of time required (Van Soest 1982). However, an important advantage of it over other methods is that many samples can be analysed simultaneously whilst retaining accuracy. Digestibility as measured by this method is highly correlated with digestible energy (Mautz et al. 1974, Milchunas et al. 1978, Moir 1961, Rittenhouse et al. 1971, Robbins et al. 1975).

Other methods of analysis of digestibility include the *in situ* nylon bag methods which involve suspending diet samples in the rumen of a fistulated animal for a prescribed period and then reweighing the samples to see how much has been digested. The *in situ* methods are very time-consuming if hundreds of samples are to be analysed. (Kartchner and Campbell 1979). Another method is to use confined animals and feed them known amounts of forage, and measure the faecal output over several days. This would have been very difficult with mouflon as they are a wild animal, and it would have been extremely difficult to collect enough forage for a digestion trial.

The Tilley and Terry two-stage in vitro digestibility analysis was carried out on the milled samples from Cyprus in batches of 58, each with 2 replicates.

0.5g of the sample was digested for 48 hrs using 50 ml of rumen inoculum, followed by 48 hrs digestion with pepsin in HCl solution at about pH 2. This procedure was carried out in a water bath at 41°C in stoppered pyrex tubes that allowed the escape of carbon dioxide but not the entry of air. The samples were then washed out of the tubes on to ash-free filter paper and dried in an oven at 100°C, reweighed, and then ashed in a furnace at 600°C and weighed again. Known weights of each sample were ashed to give organic matter content. The success of the method is related to its similarity to the ruminant digestion sequence and to the recovery of indigestible cell wall matter. (Van Soest 1982). Rumen liquor was collected from a blackface sheep *Ovis aries*, fed on high quality hay and high protein dried grass pellets. The species chosen as the source of the rumen liquor has been shown to have little importance as long as the donor animal is fed a diet similar to the animal under investigation. (Cowan et al. 1970, Scales et al. 1974, Van Dyne and Weir 1964, Welch et al. 1983). Van Dyne and Weir (1964), Palmer et al. (1976), and Scales et al. (1974) found that inocula from cattle *Bos taurus* or sheep could be used if both were fed similar diets, and Cowan et al (1970) found the same when sheep and deer were compared. It was not possible to feed the donor animal the same diet as a free-living Cyprus mouflon, but there was probably little difference in rumen physiology, as both species are sheep. Clary et al. (1988) recommended that more than one donor was used, and standard reference forages should be used to calibrate the samples. The second criterion was satisfied with the Cyprus samples, but only one sheep was used as donor.

3.2.2 Potassium, phosphorus, and nitrogen

For potassium, phosphorus, and nitrogen analysis, a modified micro-Kjeldahl digest was used (Allen et al., 1974). 0.1g of each sample was weighed into a pyrex digest tube, and 2ml of concentrated H2SO4 acid was added (in 1ml portions), followed by 1ml (added in 0.5ml drops) of 30% hydrogen peroxide. The tubes were then heated at 340°C for 5 hours after which all organic material had been destroyed and the solutions had cleared. The solutions were made up to 50ml with distilled water in volumetric flasks. Two blanks were run with every 120 samples (blanks consisting of the sulphuric acid and the hydrogen peroxide without the sample). A Pye Unicam Sp 9 atomic absorption/emission spectrophotometer was used to determine the total potassium content of each sample. Total nitrogen (as ammonium) was determined in solution using an automated colorimetric method employing the

salicylate dichloroisocyanurate reaction in the presence of nitroprusside (Crooke and Simpson 1971). The results for nitrogen were multiplied by 6.25 to give crude protein content (AOAC 1984). Total phosphorus (as phosphate) was determined in solution using an automated colorimetric method employing the molybdate blue complex, ascorbic acid being used as the reducing agent in the molybdenum system. (Murphy and Riley 1962). These methods were used because they were the most accurate and convenient ones available. The results for the different species were then arranged by plant type found to be identifiable by their epidermal characteristics (Chapter 4) and the mean for each month for each plant type taken for each of the five nutrient characteristics (moisture content, digestibility, crude protein, phosphorus and potassium). Spearman rank correlation coefficients were then used to investigate the relationships between the different nutrients. This was done firstly by type, for all months, and then by month, for all types. The efficiency of the Spearman rank correlation, when compared to the most powerful parametric correlation (the Pearson r) is about 91% (Siegel 1956)

3.3 RESULTS

The figures 3.1–3.5 show the percent of each nutrient in each plant type at different times of year. The minimum levels of each nutrient necessary for sheep maintainance are indicated. The data for each plant species is presented in Appendix 3, and the data for each plant type in Appendix 4.

3.3.1 Digestibility

Some plant types were below 50% digestibility all year. These were *Cedrus libani, Pinus brutia, Quercus alnifolia, Platanus orientalis* and *Cistus* spp. Others were mostly below 50% digestibility but were above this threshold during one or two of the months measured: *Styrax officinalis* in April; *Myrtus communis* in June; broadleaved trees in April, June and October; and fruits in April and October. Some were above or at 50% digestibility from January until June, but below during the rest of the year: *Rubus sanctus, Teucrium kotschyanum*, and *Pistacia terebinthus/Trifolium clypeatum*. Finally, there was a group of plants which were above 50% digestibility all year, often 65–80%. These were the non-graminaceous monocots, the grasses, forbs and *Asphodelus aestivus*.

Fig 3.1

Percent *in vitro* dry matter digestibility of plant types over the year.

The 50% level is indicated, as the threshold of forage below which a ruminant cannot maintain itself (Amman et al 1973). Cedrus=*Cedrus libani ssp. brevifolia*; Fruits=fruits of *Styrax officinalis*, *Arbutus andrachne*, *Quercus alnifolia*; Broadleaf=all broadleaved trees unless otherwise specifically mentioned; Cistus=*Cistus salviifolius* and *C. creticus*; Asphodel=*Asphodelus aestivus*; Pistacia=*Pistacia terebinthus* and *Trifolium clypeatum*. Samples were collected in Jan, Feb, Apr, Jun, Aug, Oct, Nov. No data=*

Standard error bars are indicated.

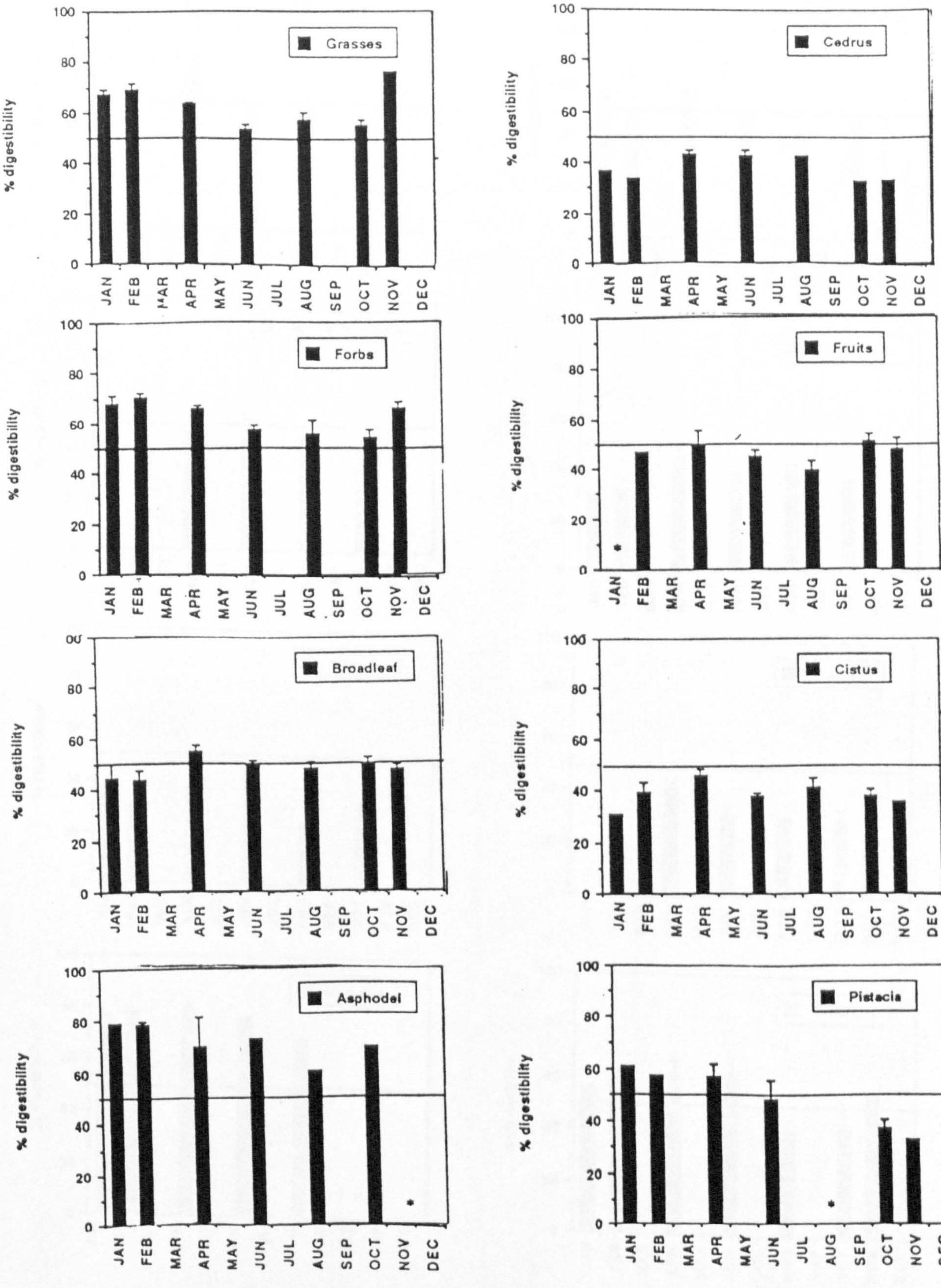
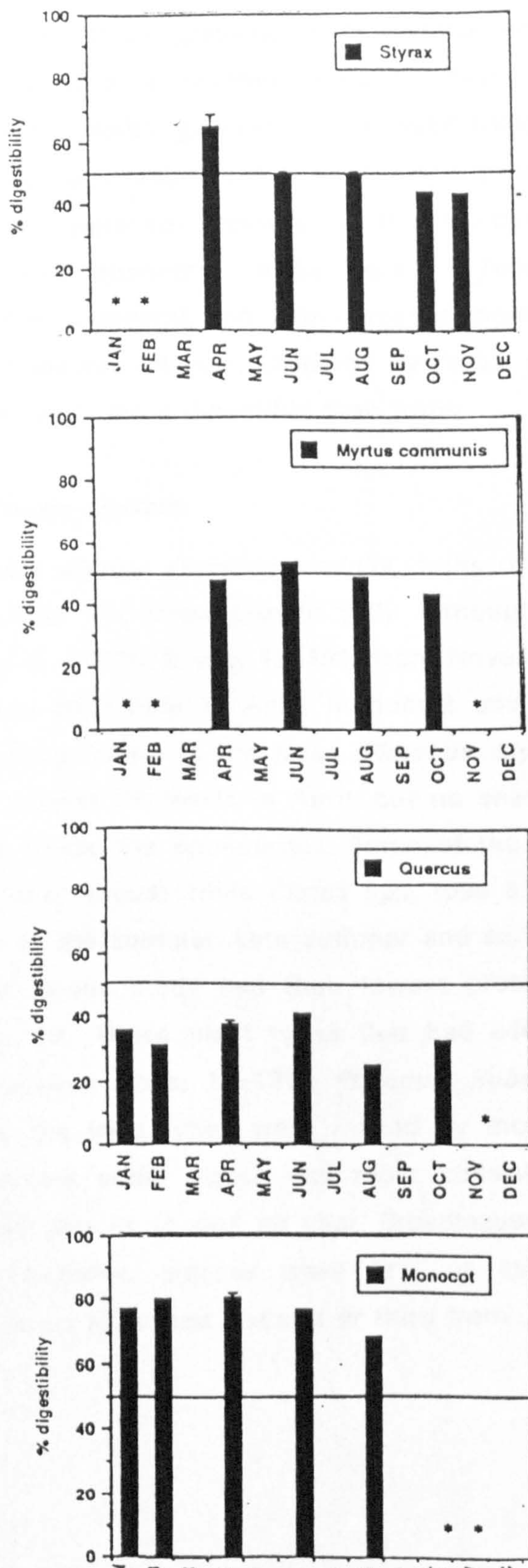


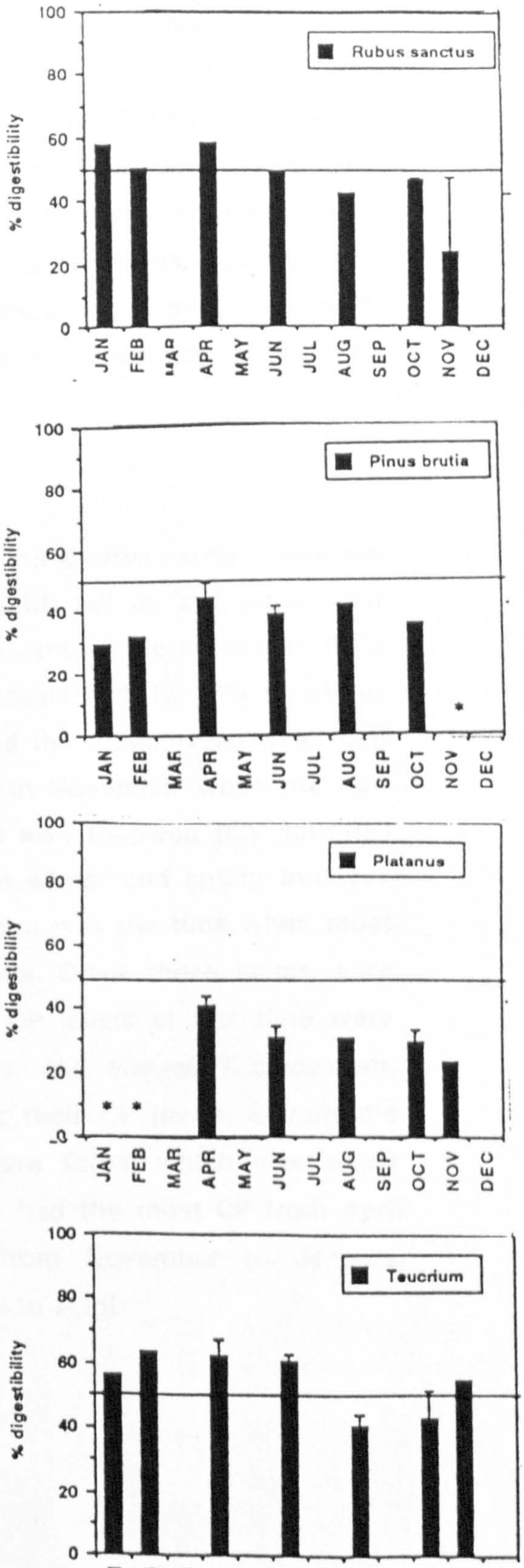
Fig 3.1

Percent *in vitro* dry matter digestibility of plant types over the year. (Cont.)

The 50% level is indicated, as the threshold of forage below which a ruminant cannot maintain itself (Amman et al 1973). Styrax=*Styrax officinalis*; Rubus=*Rubus sanctus*; Quercus=*Quercus alnifolia*; Platanus=*Platanus orientalis*; Monocots=non-graminaceous monocotyledons; Teucrium=*Teucrium kotschyanum*; Samples were collected in Jan, Feb, Apr, Jun, Aug, Oct, Nov. No data=*

Standard error bars are indicated.





These were most digestible in the wet season, least in the summer. Grasses and forbs were 65-75% digestible from November until April; and 54-57% during the summer. Monocots were 70-80% digestible from January until August. *Asphodelus* was 60-73% digestible in the summer. When these plants were ranked in order of digestibility each month, *Cistus* spp. were always ranked bottom among the plants most commonly eaten by mouflon (Monocots, *Asphodelus*, forbs, grasses, *Teucrium* and broadleaved trees) (Chapter 4). The most digestible in summer were (in descending order): Monocots/*Teucrium, Asphodelus*, forbs, grasses, broadleaved trees, *Cistus* spp. During the autumn the order was: *Asphodelus*, grass, forbs, broadleaves, *Teucrium, Cistus* spp. (Monocots were not measured in this season). In winter and in spring it was: *Asphodelus*/Monocots, forbs, grass, *Teucrium*, broadleaves, *Cistus* spp. Therefore in general, non graminaceous monocots (including *Asphodelus*) were most digestible all year, followed by forbs, grasses and *Teucrium*. In autumn, grasses were more digestible than forbs.

3.3.2 Crude protein

Pinus, Myrtus, Quercus alnifolia, fruits of trees and *Cedrus* rarely contained more than 7% crude protein (CP). Although grass CP fell in late winter and spring to 8-10%, it was 15-18% from November to January. Forbs had 15-19% CP from November to April; monocots and *Asphodelus* had 12-18% in winter and spring. Some of the trees (*Platanus, Styrax* and the broadleaved trees had their highest CP levels in April, but no sharp rise in November when the rain starts, unlike the ephemerals. Some of the shrubs also followed this pattern (*Teucrium, Rubus*) while *Cistus* spp. rose a little in winter and spring but was lower in the summer. Late summer and early autumn was the time when most plants in the study had their lowest protein levels. Often these levels were below 7%. Those plant types that had adequate CP levels at this time were broadleaved trees, 11-13%; *Platanus, Rubus* forbs, and *Pistacia/T. clypeatum*. When the food types were ranked by month for their CP levels, among the commonly eaten plants, the most consistent were forbs, which was either ranked first or second all year. Broadleaved trees had the most CP from April until October, grasses were first or second from November to January, monocots were first, second or third from January to April.

Fig 3.2

Crude protein content of plant types through the year, as a percentage of dry weight.

Measured as 6.25x%nitrogen content of dry weight (AOAC 1984). The 5% and 7% levels are indicated, as the minimum threshold for nitrogen balance for sheep (Mould & Robbins 1981, Robbins et al 1975). Cedrus=*Cedrus libani ssp. brevifolia*; Fruits=fruits of *Styrax officinalis, Arbutus andrachne, Quercus alnifolia*; Broadleaf=all broadleaved trees unless otherwise specifically mentioned; Cistus=*Cistus salviifolius* and *C. creticus*; Asphodel=*Asphodelus aestivus*; Pistacia=*Pistacia terebinthus* and *Trifolium clypeatum*. Samples were collected in Jan, Feb, Apr, Jun, Aug, Oct, Nov. No data=*

Standard error bars are indicated.

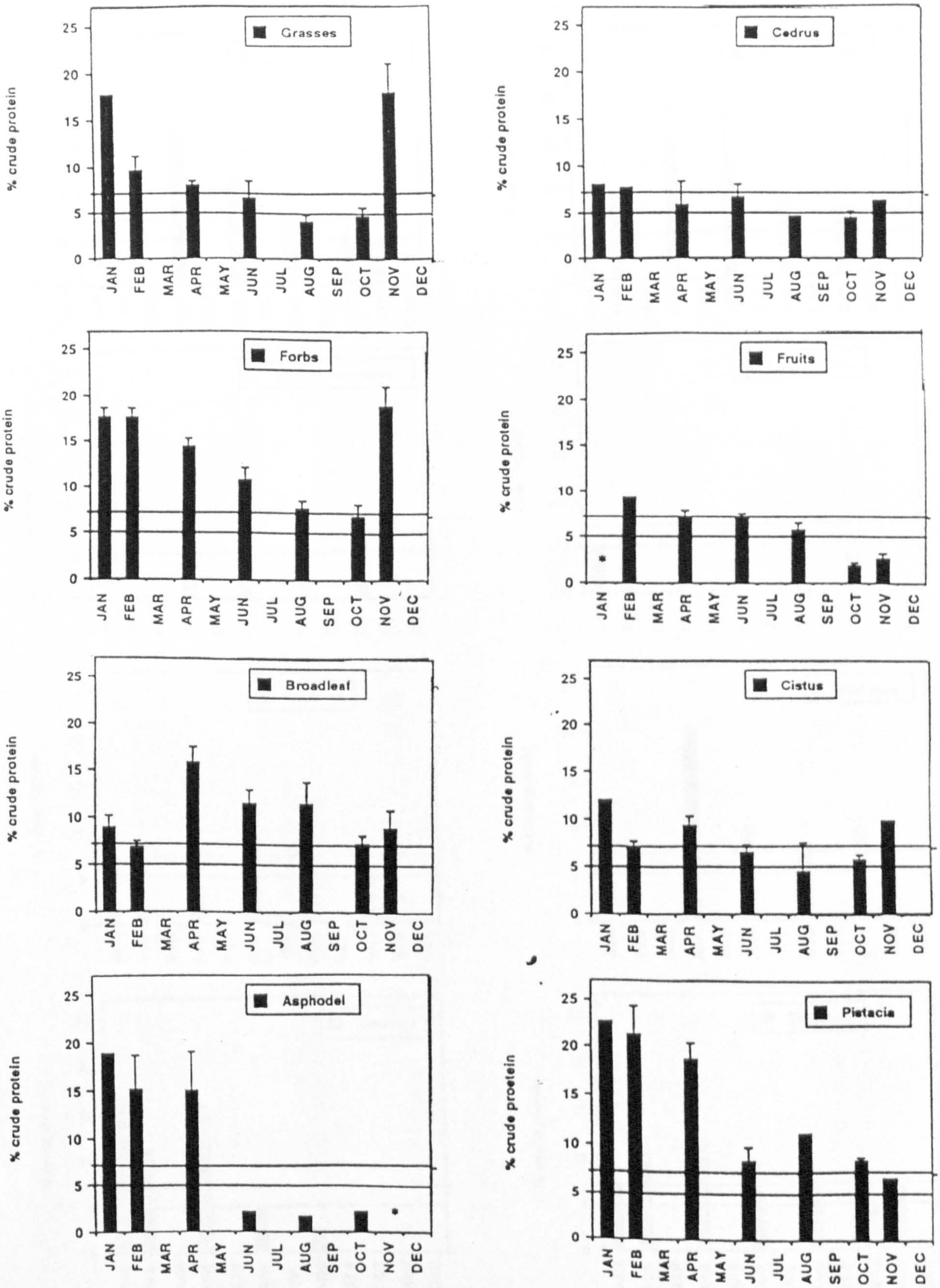
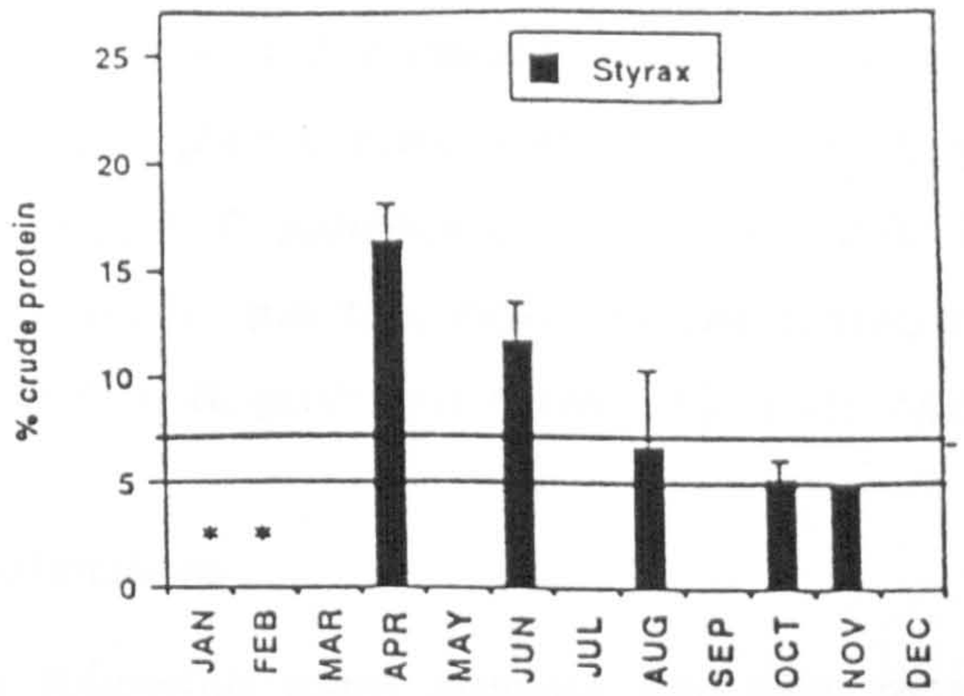
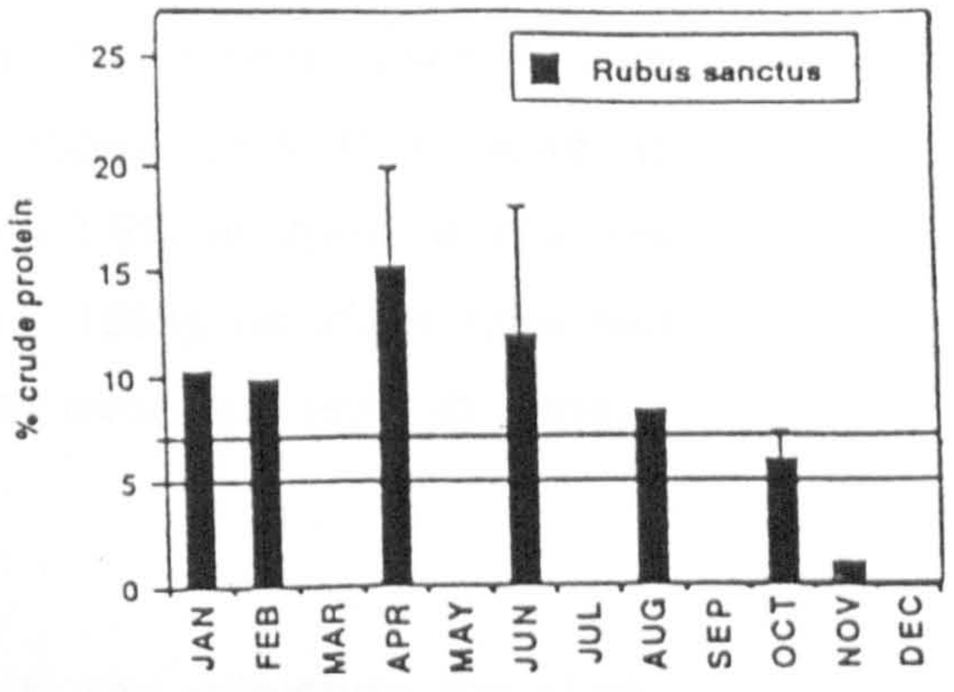


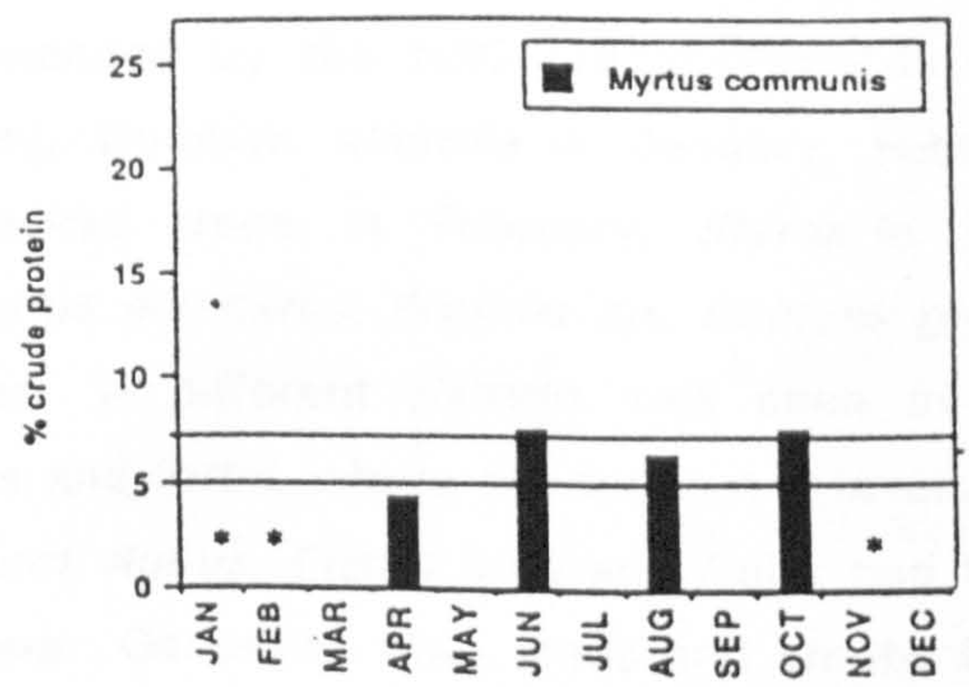
Fig 3.2

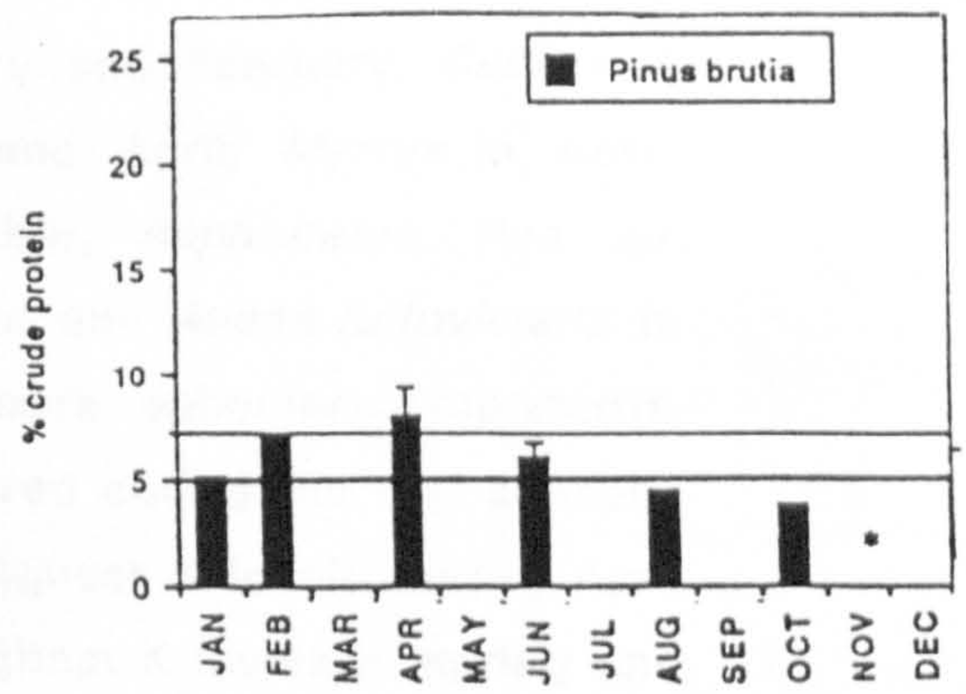
Crude protein content of plant types through the year, as a percentage of dry weight. (Cont.)

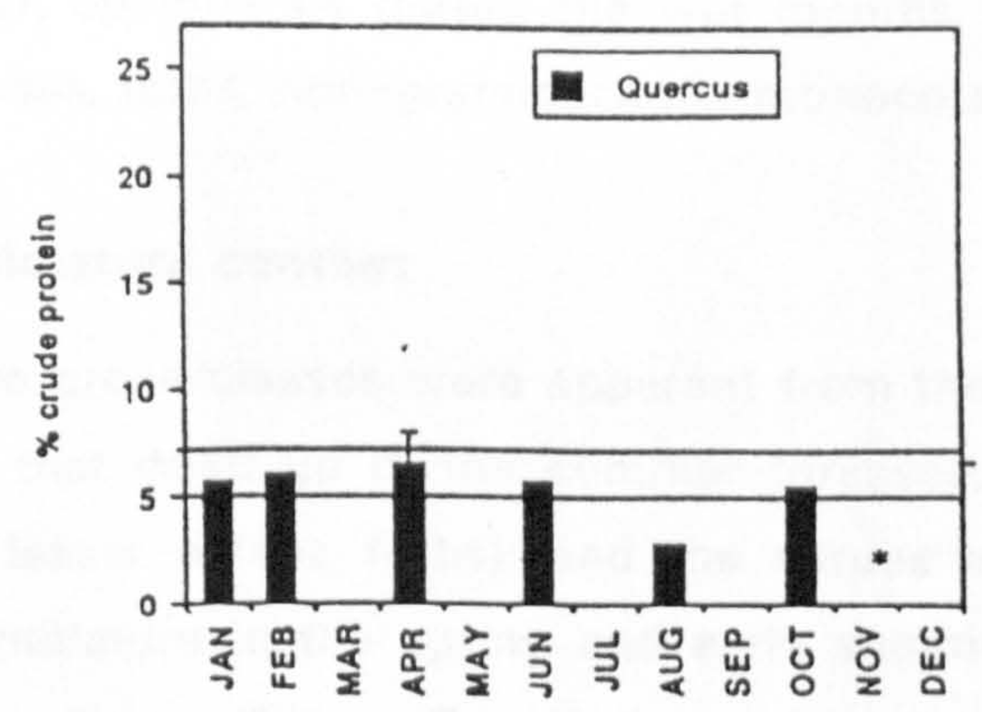
Measured as 6.25x%nitrogen content of dry weight (AOAC 1984). The 5% and 7% levels are indicated, as the minimum threshold for nitrogen balance for sheep (Mould & Robbins 1981, Robbins et al 1975). Styrax=*Styrax officinalis*; Rubus=*Rubus sanctus*; Quercus=*Quercus alnifolia*; Platanus=*Platanus orientalis*; Monocots=non-graminaceous monocotyledons; Teucrium=*Teucrium kotschyanum*; Samples were collected in Jan, Feb, Apr, Jun, Aug, Oct, Nov. No data=* Standard error bars are indicated.

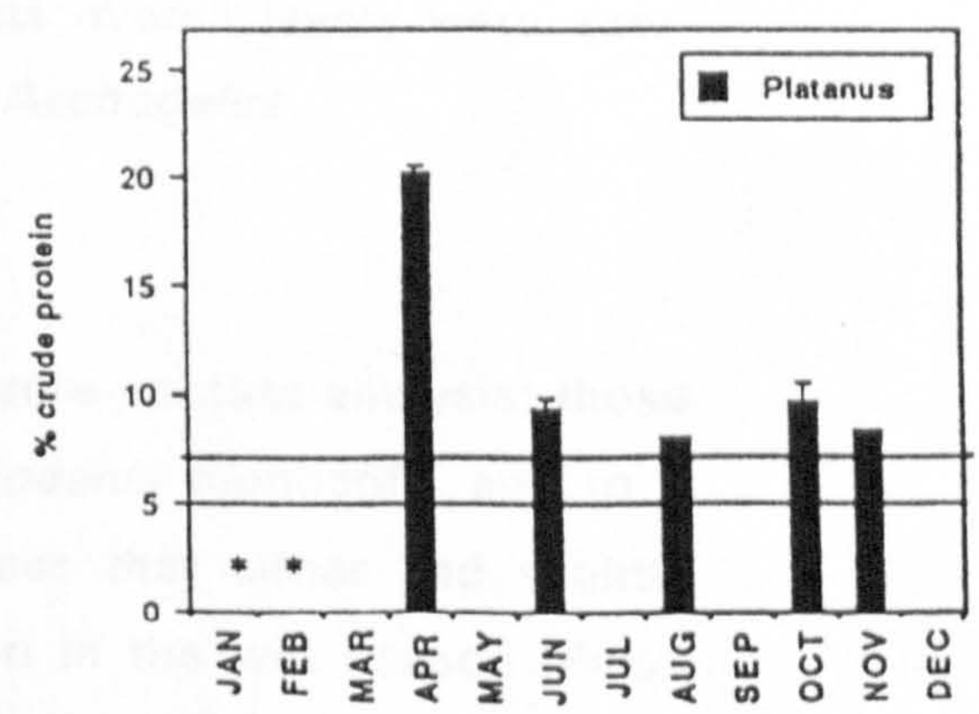


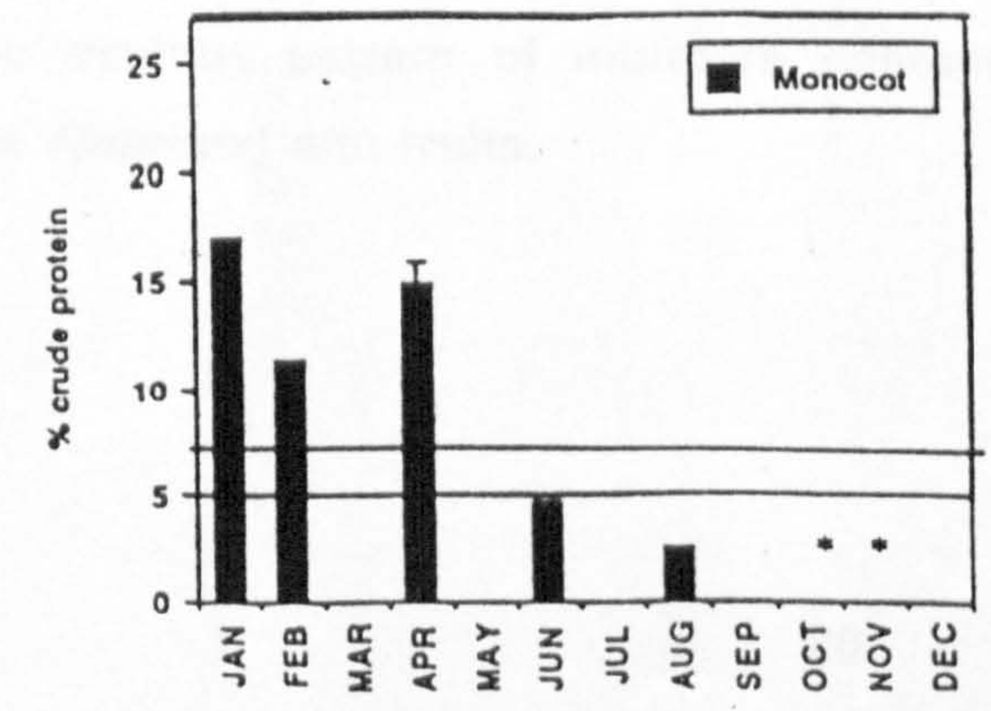


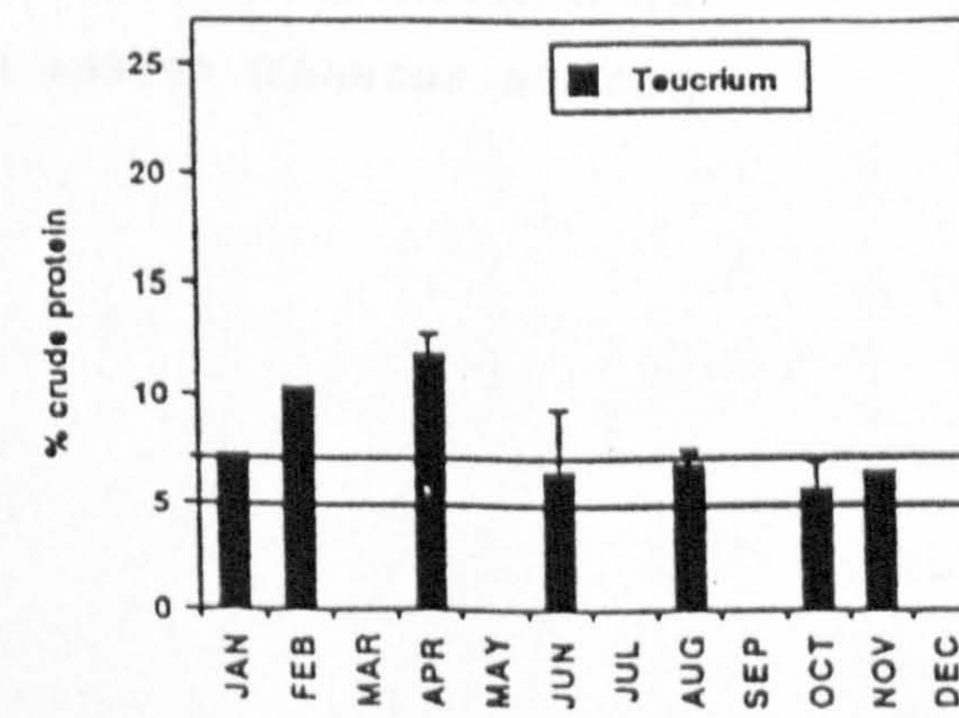












3.3.3 Phosphorus

Plant types with P levels at or below 2.5% all year were: *Myrtus, Pinus*, and fruits. Except for the month of April, the following were below 2.5% all year: *Cedrus, Platanus, Quercus alnifolia, Styrax*, and broadleaved trees. In other words, all the trees were low in P content. Grasses, forbs, monocots, *Rubus, Asphodelus*, and *Pistacia/T. clypeatum* all had higher levels of P in the winter and spring than in the summer, and levels rose again in autumn in grasses forbs and *Pistacia/T. clypeatum*. Summer seemed to be a time when P was low in most plants measured. No plant type was above 2.5% P in June or August except *R. sanctus*:2.7% in June and *Teucrium*:3.5% in June. If the 2% level is used as the threshold, as suggested by Short (1981), no plant type had sufficient P in August; but forbs and fruits had slightly over that level in June.

3.3.4 Potassium

The following plant species had less than 0.5% K, the minimum for sheep recommended by the NRC (1975): *Pinus* in January and February; *Cedrus* in February; *Quercus alnifolia* in January, February and April; *Myrtus* in April; broadleaved trees in February, *Styrax* in November, *Asphodelus, Poa sp., Cynosurus echinatus, Bromus sp., Dactylis glomerata* and *Avena ludoviciana* in October. A different pattern was seen in the more ephemeral monocots, grasses and forbs, where the highest K levels occurred during the wet season. *Teucrium, Rubus, Cistus* spp. and fruits had their highest K levels during April and June. Generally, then, trees and shrubs had highest K levels in spring and summer, ephemerals during the wet months. Highest overall levels were seen in grasses, forbs, non-graminaceous monocots, and *Asphodelus*.

3.3.5 Moisture content

Two broad classes were apparent from the moisture content analysis: those plants that dried up in the summer (grasses, *Asphodelus* monocots, and to a much lesser extent, forbs); and the shrubs and trees that either had slightly more moisture in the spring and early summer than in the wet season (*Pinus, Cedrus, Rubus, Styrax, Teucrium* and broadleaved trees); or those where there was no obvious pattern of moisture content with season (*Quercus alnifolia, Myrtus, Platanus*) and fruits.

Fig 3.3

Phosphorus content of plant types through the year as a percentage of dry weight.

The 0.2% -0.25% levels are indicated as these are the estimated minimum requirements for sheep (Short 1981, NRC 1975). Cedrus=*Cedrus libani ssp. brevifolia*; Fruits=fruits of *Styrax officinalis, Arbutus andrachne, Quercus alnifolia*; Broadleaf=all broadleaved trees unless otherwise specifically mentioned; Cistus=*Cistus salviifolius* and *C. creticus*; Asphodel=*Asphodelus aestivus;* Pistacia=*Pistacia terebinthus* and *Trifolium clypeatum.* Samples were collected in Jan, Feb, Apr, Jun, Aug, Oct, Nov. No data=*
Standard error bars are indicated.

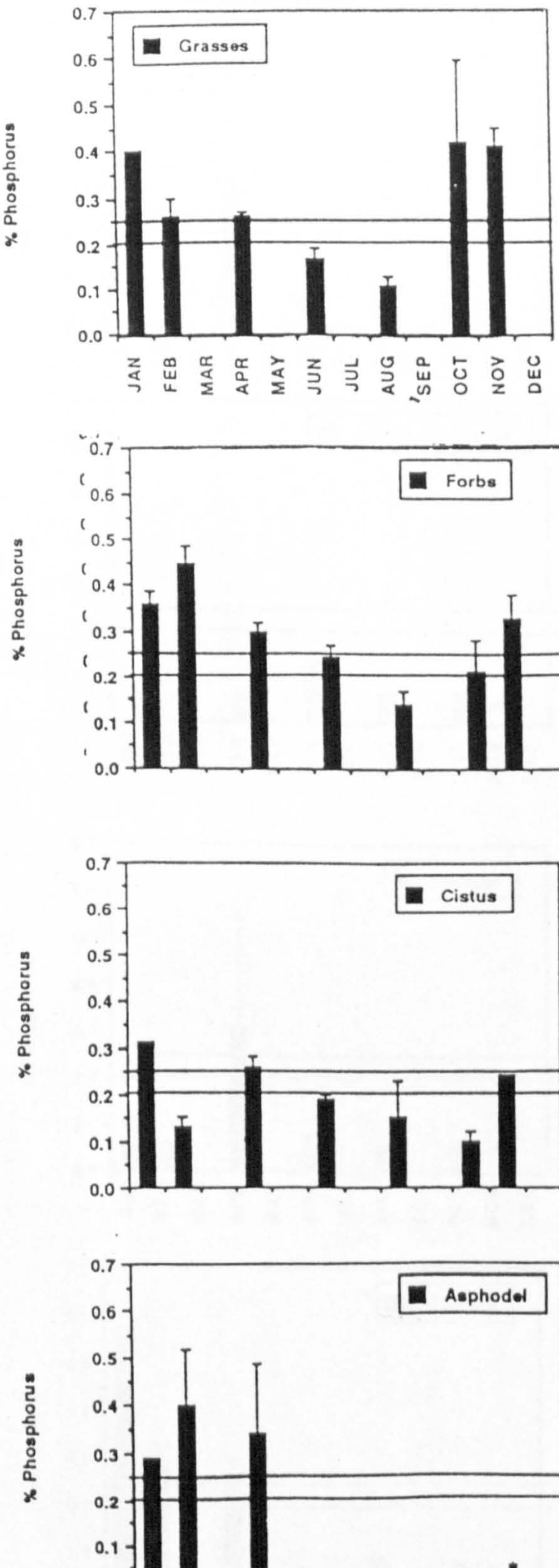


Fig 3.3

Phosphorus content of plant types through the year as a percentage of dry weight. (Cont.)

The 0.2% -0.25% levels are indicated as these are the estimated minimum requirements for sheep (Short 1981, NRC 1975). Styrax=*Styrax officinalis*; Rubus=*Rubus sanctus*; Quercus=*Quercus alnifolia*; Platanus=*Platanus orientalis*; Monocots=non-graminaceous monocotyledons; Teucrium=*Teucrium kotschyanum*; Samples were collected in Jan, Feb, Apr, Jun, Aug, Oct, Nov. No data=* Standard error bars are indicated.

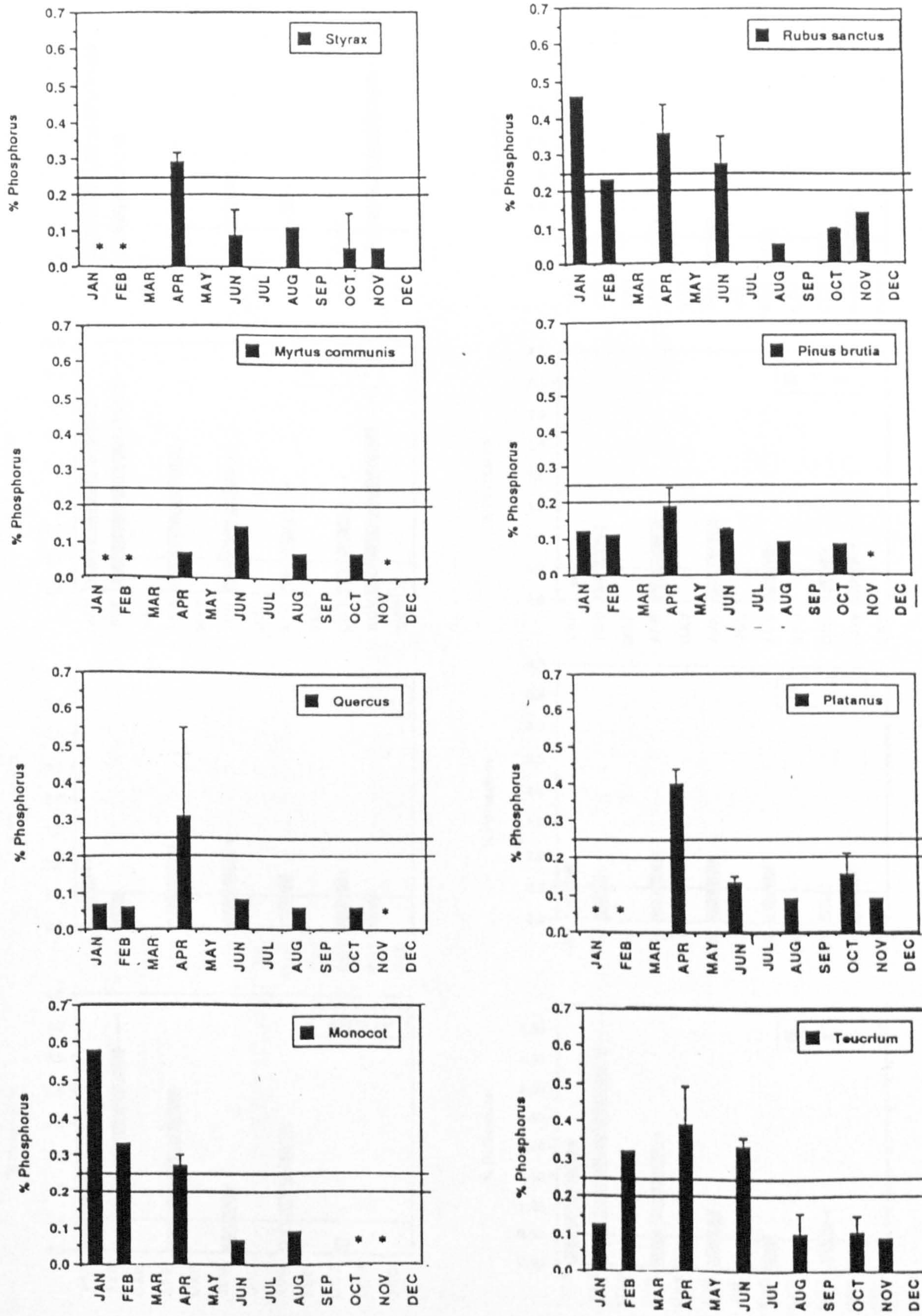
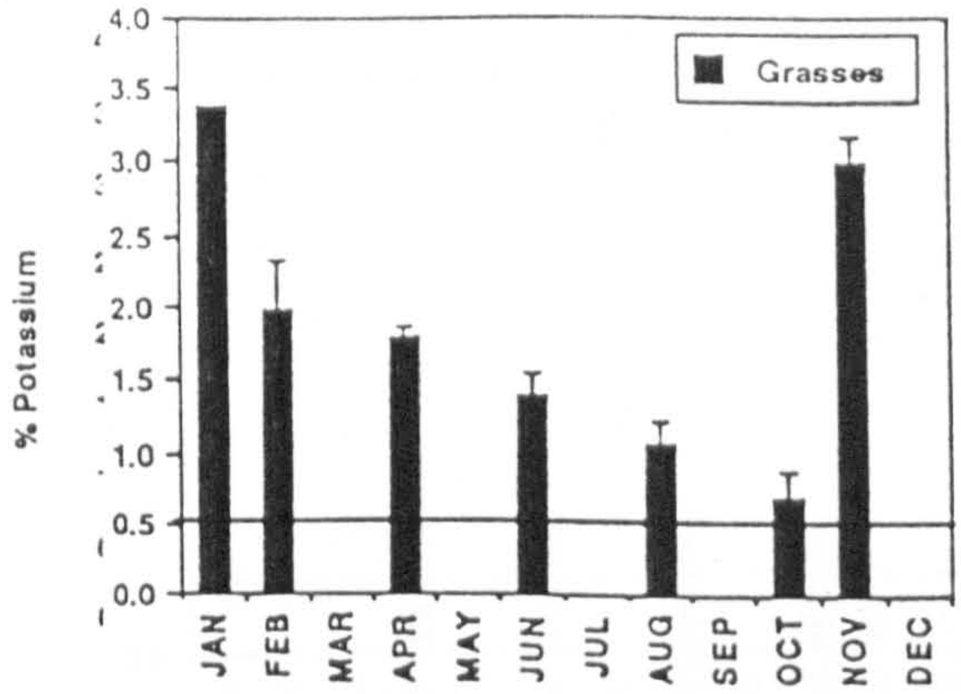


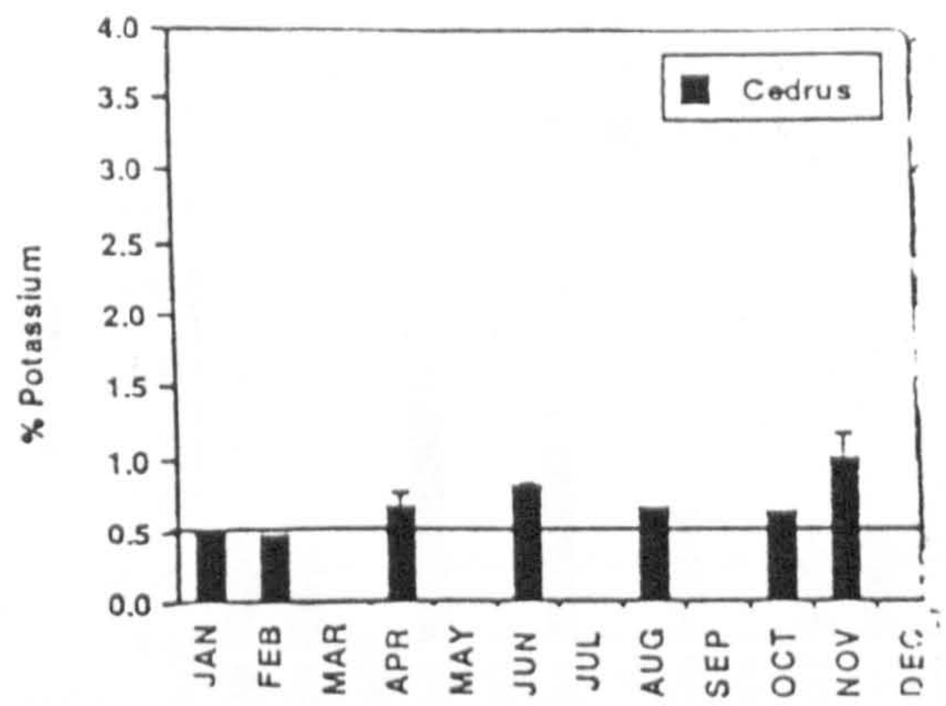
Fig 3.4

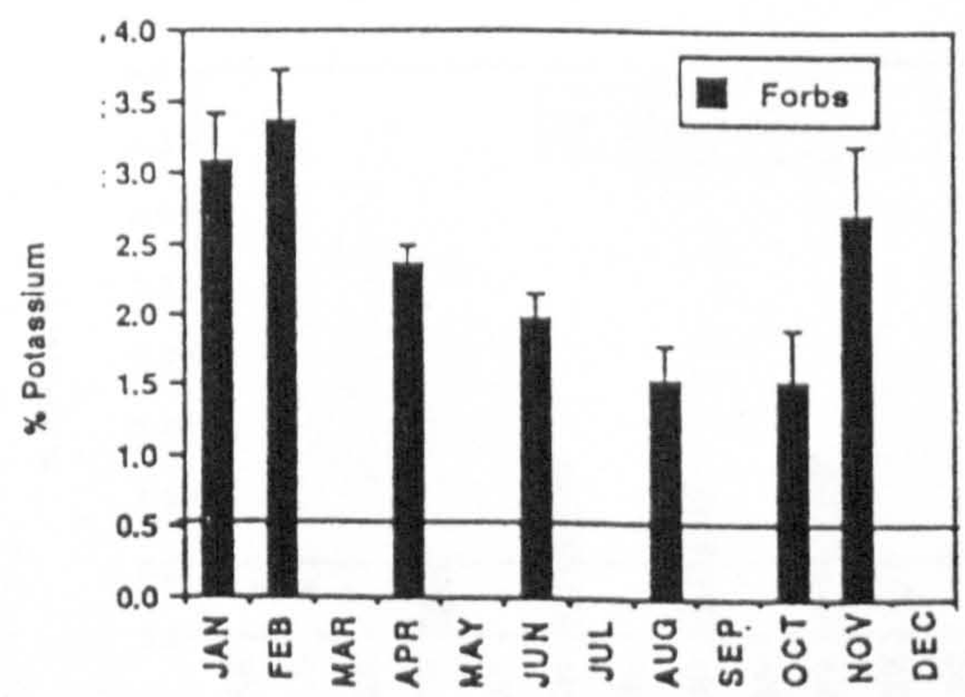
Potassium content of plant types through the year as a percentage of dry weight.

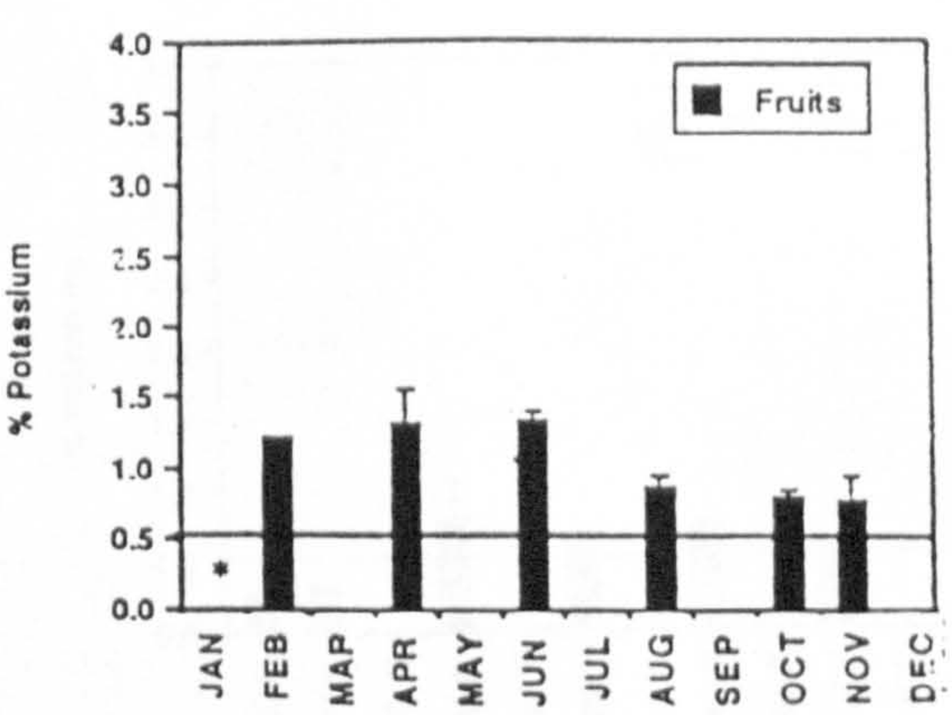
The 0.5% level is indicated as this is the estimated minimum requirement for sheep (NRC 1975). Cedrus=*Cedrus libani ssp. brevifolia*; Fruits=fruits of *Styrax officinalis, Arbutus andrachne, Quercus alnifolia*; Broadleaf=all broadleaved trees unless otherwise specifically mentioned; Cistus=*Cistus salviifolius* and *C. creticus;* Asphodel=*Asphodelus aestivus;* Pistacia=*Pistacia terebinthus* and *Trifolium clypeatum.* Samples were collected in Jan, Feb, Apr, Jun, Aug, Oct, Nov. No data=*

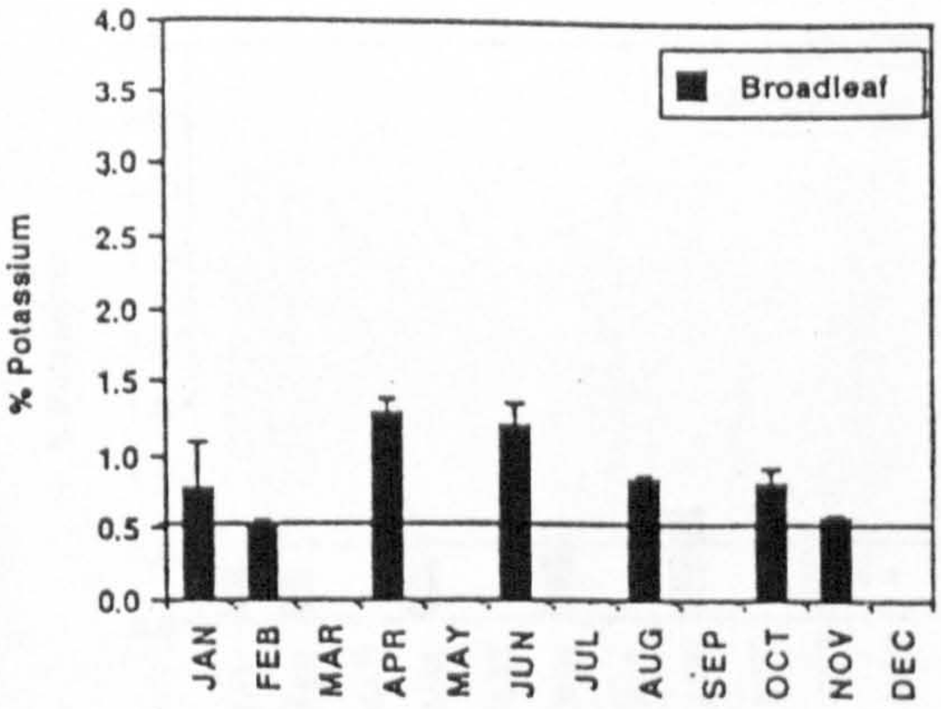
Standard error bars are indicated.

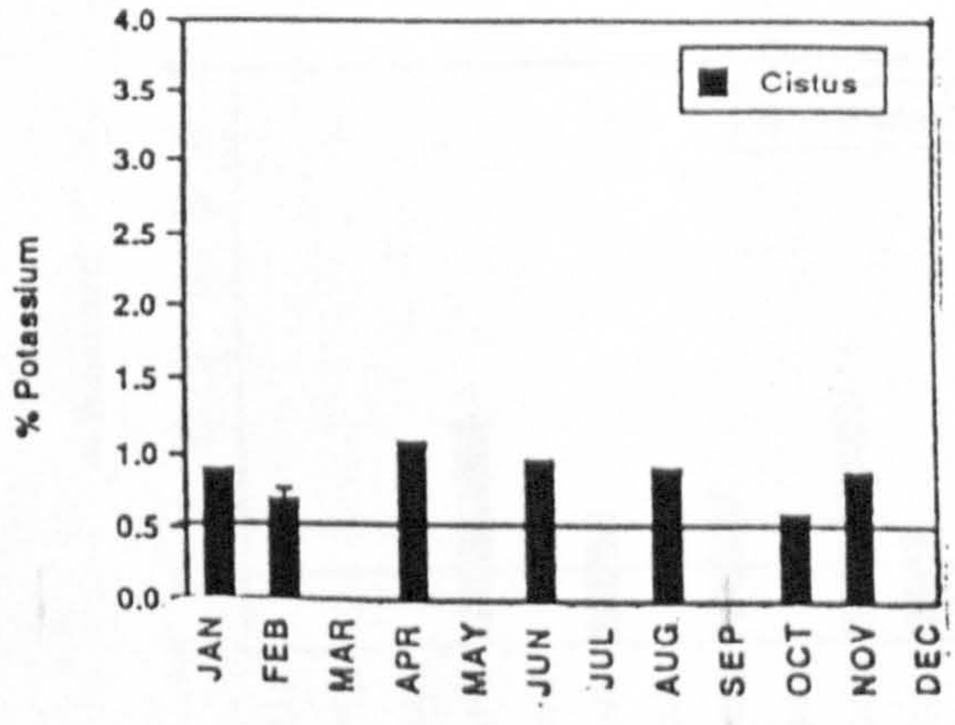


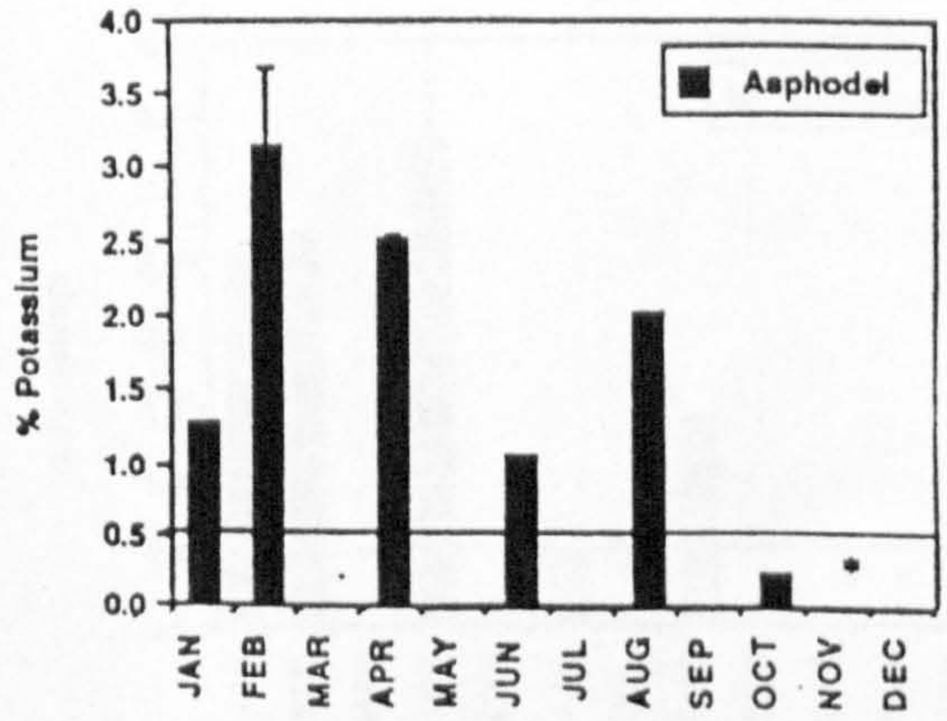












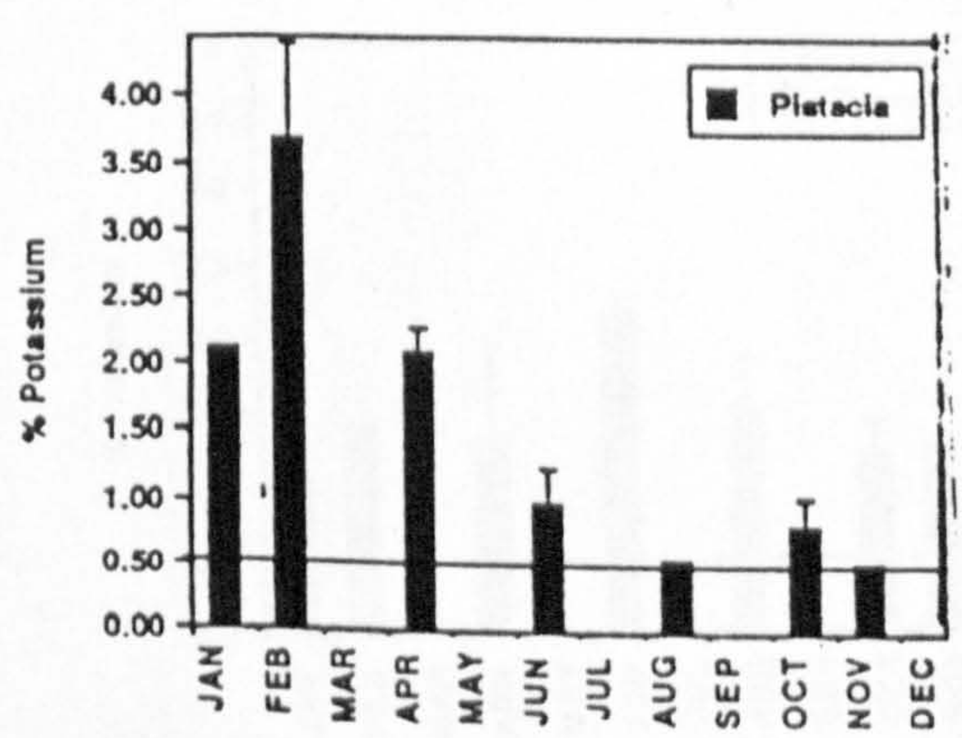


Fig 3.4

Potassium content of plant types through the year as a percentage of dry weight. (Cont.)

The 0.5% level is indicated as this is the estimated minimum requirement for sheep (NRC 1975). Styrax=*Styrax officinalis*; Rubus=*Rubus sanctus*; Quercus=*Quercus alnifolia*; Platanus=*Platanus orientalis*; Monocots=non-graminaceous monocotyledons; Teucrium=*Teucrium kotschyanum*; Samples were collected in Jan, Feb, Apr, Jun, Aug, Oct, Nov. No data=* Standard error bars are indicated.

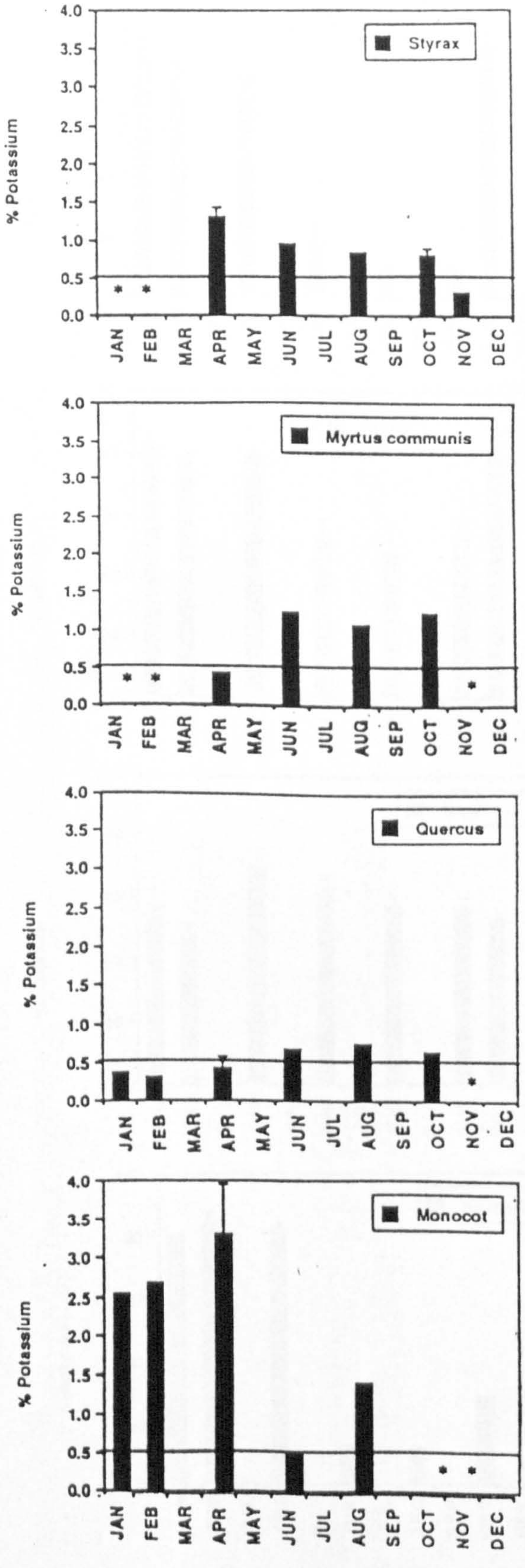


Fig 3.5

Moisture content of plant types through the year.

Cedrus=*Cedrus libani ssp. brevifolia*; Fruits=fruits of *Styrax officinalis, Arbutus andrachne, Quercus alnifolia*; Broadleaf=all broadleaved trees unless otherwise specifically mentioned; Cistus=*Cistus salvifollus* and *C. creticus;* Asphodel=*Asphodelus aestivus;* Pistacia=*Pistacia terebinthus* and *Trifolium clypeatum.* Samples were collected in Jan, Feb, Apr, Jun, Aug, Oct, Nov. No data=*

Standard error bars are indicated.

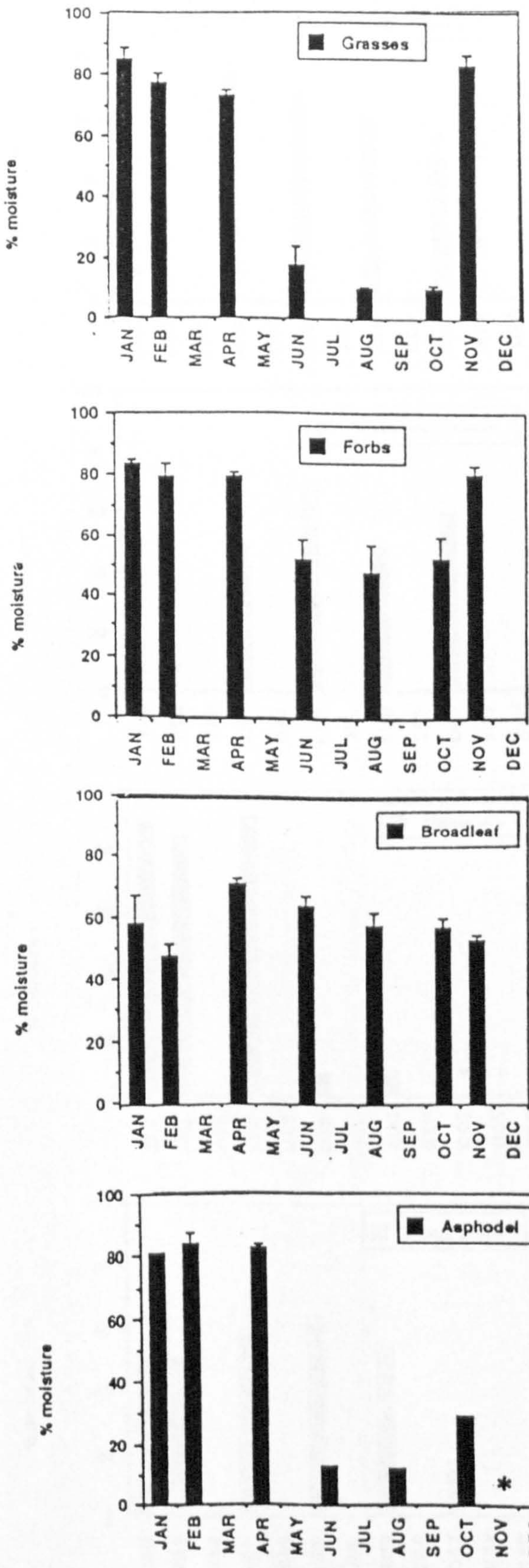
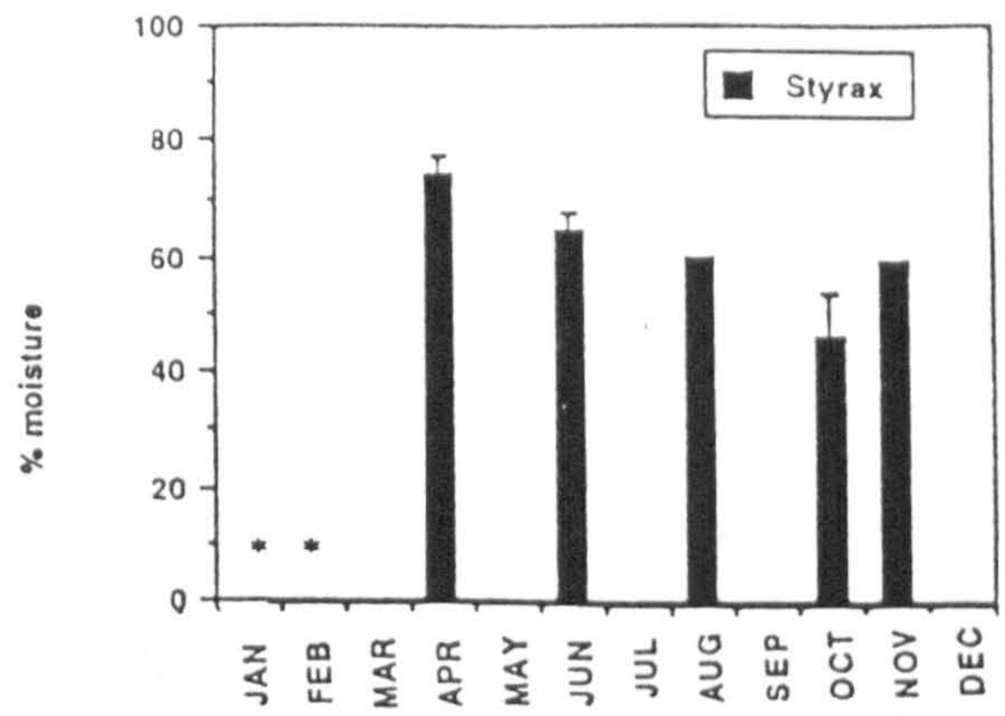
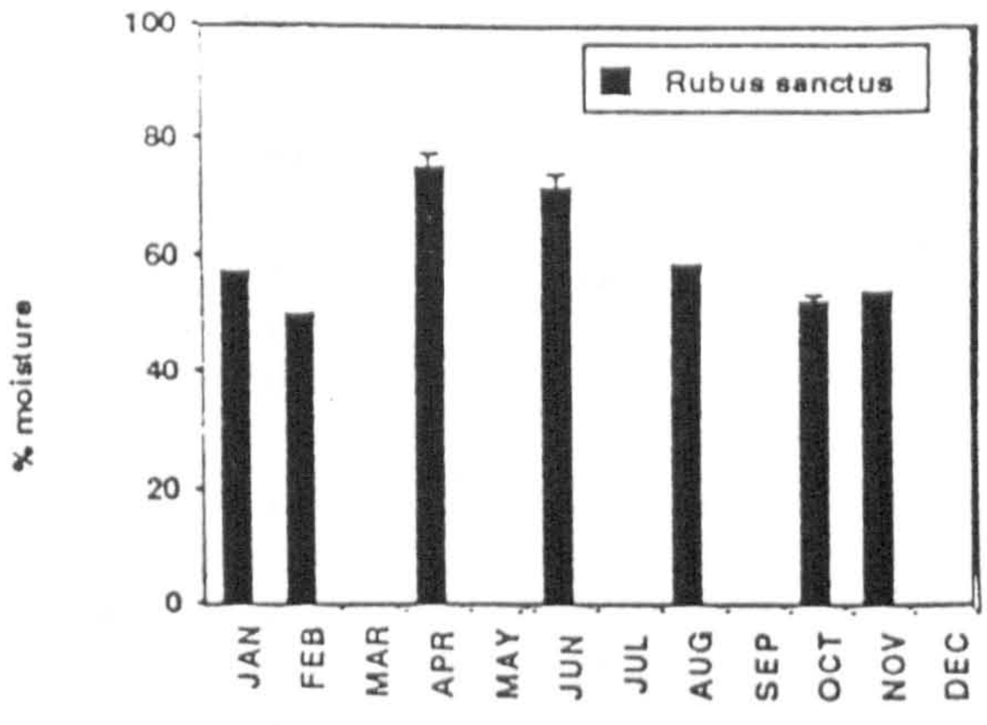
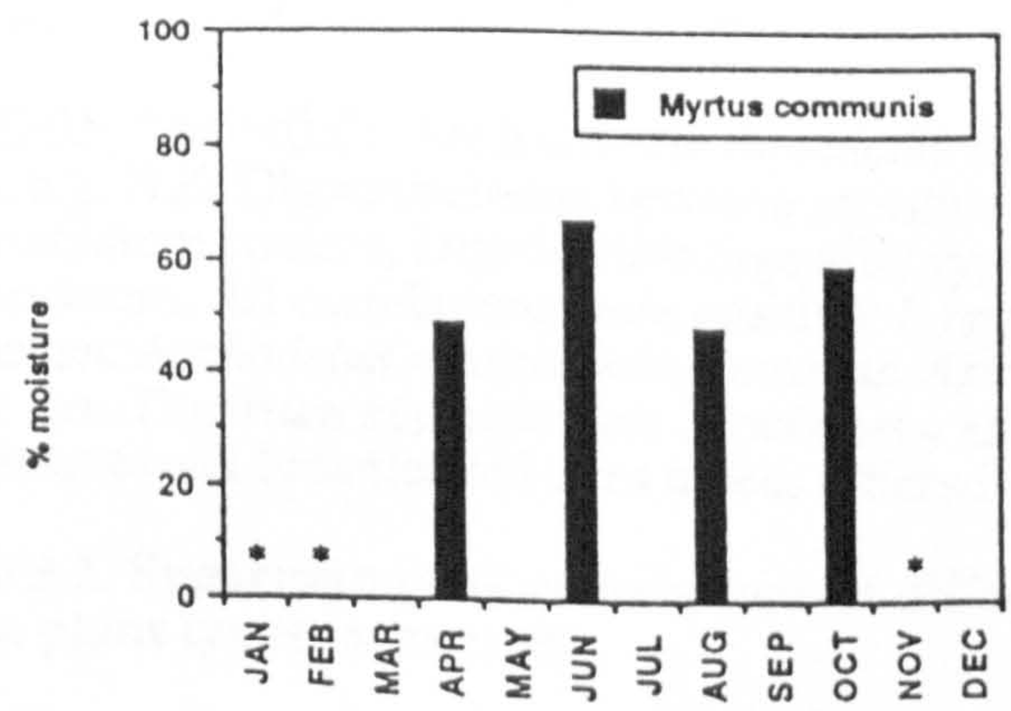


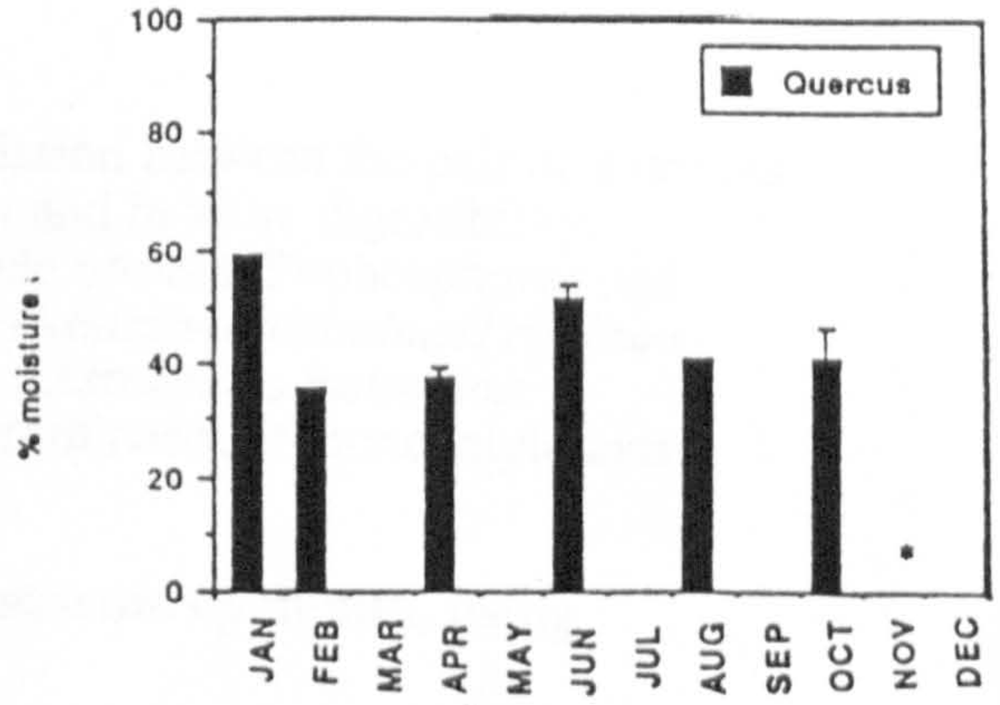
Fig 3.5

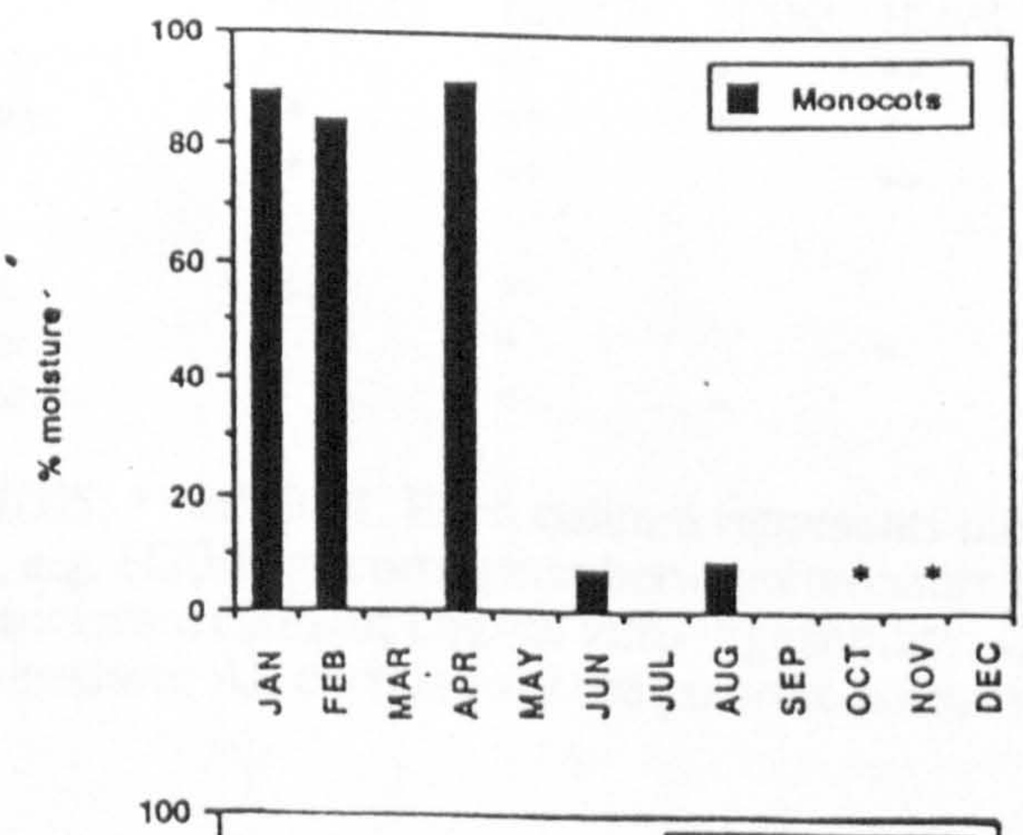
Moisture content of plant types through the year. (Cont.)
Styrax=*Styrax officinalis*; Rubus=*Rubus sanctus*; Quercus=*Quercus alnifolia*; Platanus=*Platanus orientalis*; Monocots=non-graminaceous monocotyledons; Teucrium=*Teucrium kotschyanum*; Samples were collected in Jan, Feb, Apr, Jun, Aug, Oct, Nov. No data=*
Standard error bars are indicated.

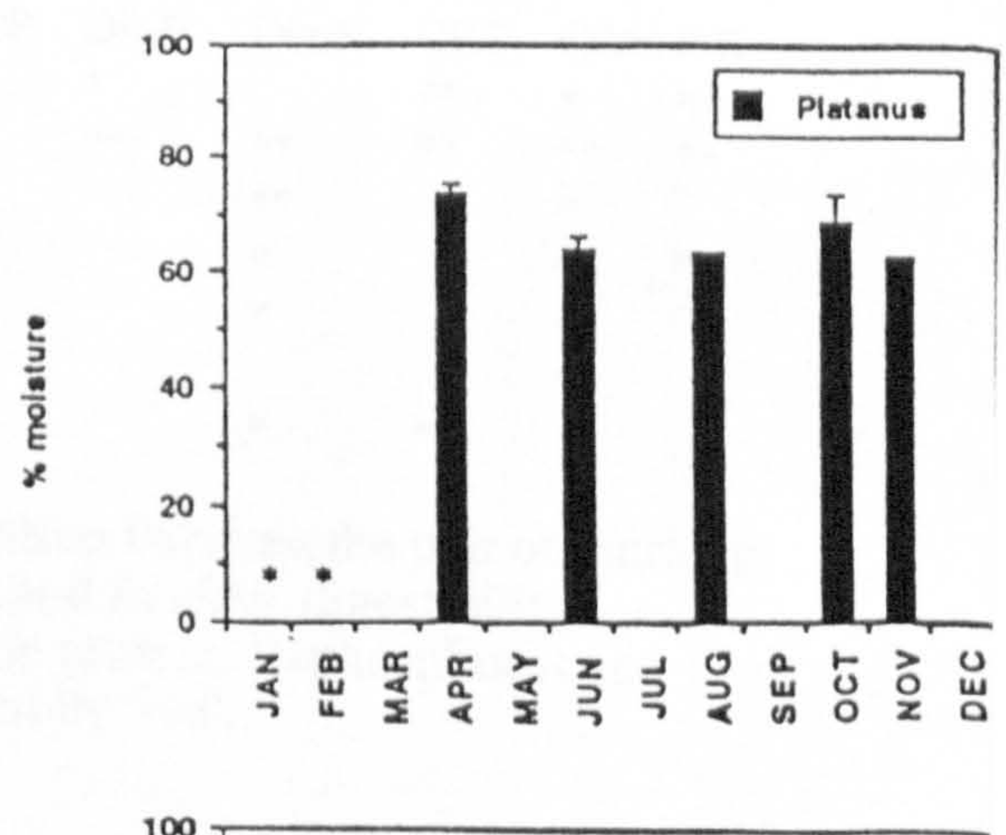


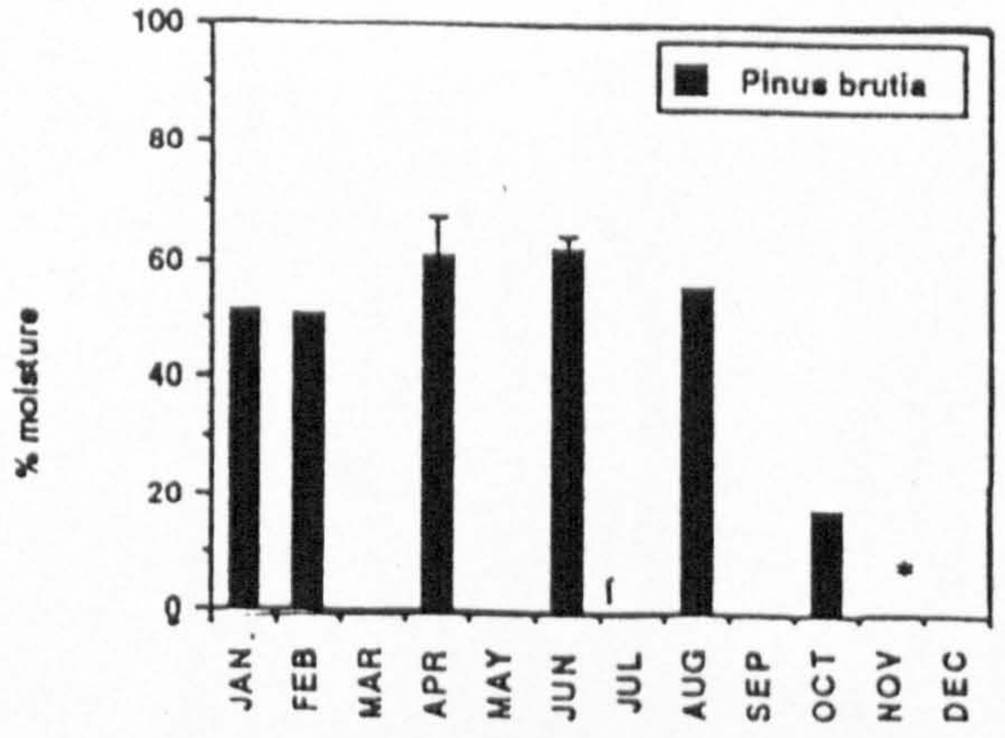












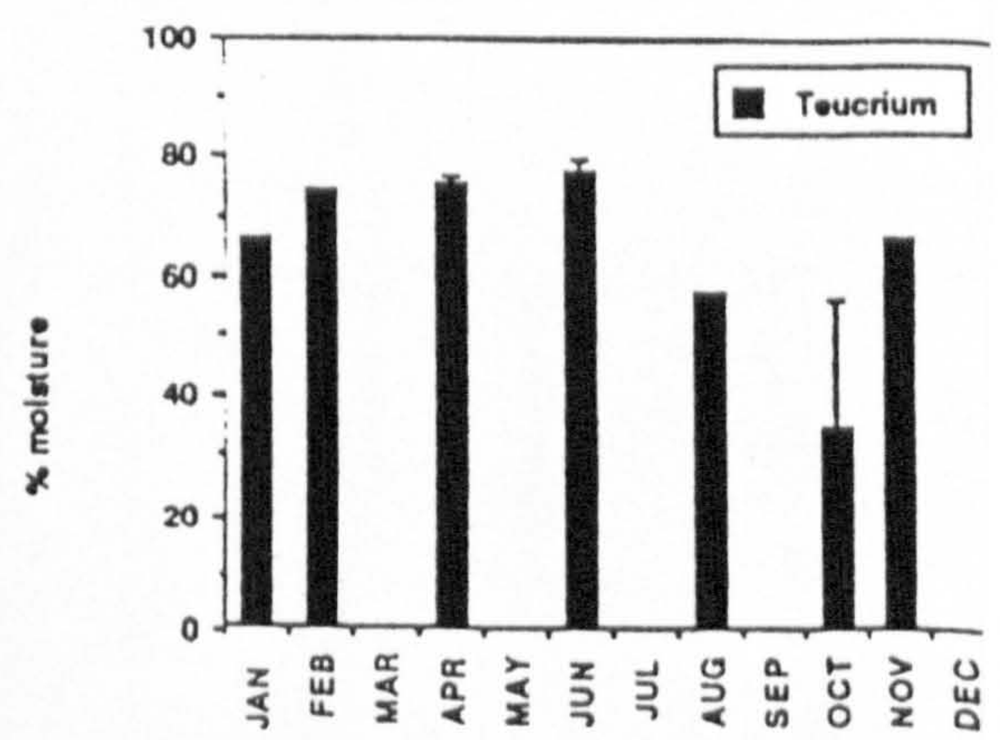


Table 3.1. Spearman rank correlations of different nutrients by plant type.

Plant type	H20/Dig	H20/CP	H20/P	H20/K	Dig/CP	Dig/P	Dig/K	CP/P	CP/K	P/K
Asphodelus			*		*					*
Astragalus								*		
Broadleaves		*	*	**			*		*	
Cedrus libani	*									
Cistus spp.		**	**					*		
Forbs	*	*	*	*	*	**	**	*	**	**
Fruits								**		
Grasses	*	**		**	*		*		**	
P.ter/T.cly			*		**		*		*	
Monocots				*			*			
Myrtus communis										
Pinus brutia							**	*		
Platanus orientalis		*	*					*		
Quercus alnifolia						*				
Rubus sanctus				**	*	*		*	*	
Styrax officinalis	*	*		*	**		**		**	
Teucrium	*		*		*	*				

*=P<0.05; **=P<0.01. Each column represents the correlation between the pair of nutrients listed, e.g. H20/Dig=correlation between moisture content and *in vitro* digestibility. H20=moisture content; Dig=*in vitro* digestibility; CP=crude protein; P=phosphorus and K=Potassium. All correlations were positive. *P.ter/T. cly=Pistacia terebinthus/Trifolium clypeatum. Asphodelus =Asphodelus aestivus. Astragalus =Astragalus lusitanica. Teucrium=Teucrium kotschyanum.* Monocots= all non-graminaceous monocotyledons. Broadleaves=all broadleaved trees unless otherwise listed.

Table 3.2. Spearman rank correlations of different nutrients by month, using all the plant types measured.

	H20/Dig	H20/CP	H20/P	H20/K	Dig/CP	Dig/P	Dig/K	CP/P	CP/K	P/K
January	*	**	**	**		*		**	*	**
February	**	**	**	**	**	**	**	**	**	**
April	**	**		**			**		*	
June							*		*	**
August	-ve*	**					*			
October		*		*					*	
November		*	*				*	*		

*=P<0.05; **=P<0.01. Each column represents the correlation between the pair of nutrients listed, e.g. H20/Dig=correlation between moisture content and *in vitro* digestibility. H20=moisture content; Dig=*in vitro* digestibility; CP=crude protein; P=phosphorus and K=Potassium. All correlations are positive unless indicated by '-ve'.

3.3.5.1 Correlations between different nutrients

1. By species. (Table 3.1.)

All nutrients were correlated in forbs. All nutrients were also correlated in grasses except for phosphorus, which was not correlated with any other nutrient. In addition, crude protein was positively correlated with digestibility in *A. aestivus, R. sanctus, T. kotschyanum, S. officinalis, and P.terebinthus/T. clypeatum*.

2. By month (Table 3.2).

All the plant types were included in this analysis. Crude protein and water content were positively correlated each month except June. All nutrients were correlated in February. This was also the case in April with the exception of phosphorus, which was not significantly correlated with any other nutrient. In January, too, all nutrients were correlated with each other except that digestibility was not correlated with either crude protein or potassium. In other words, during most of the middle to late wet season, most nutrients were correlated with each other.

3.4 DISCUSSION

As grasses mature, they become less digestible (Hobbs et al. 1981, Schwartz & Ellis 1981) because the lignin fraction of the cell wall increases with age, as does the amount of cellulose and other carbohydrates (Crampton et al. 1960, Van Soest 1965, Waring & Schlesinger 1985).The digestibility of browse is also inversely correlated with maturity (Drozdz 1979). The rate of digestibility of a plant is inversely related to the proportion of cell wall contents and the extent of digestibility is inversely related to the degree of lignification (Short et al. 1974). In Mediterranean climates, grasses and forbs commence growth at the onset of the autumn rains; but growth speeds up when temperatures increase in late March/early April. Their growth is at a peak in late April/early May, and by mid June most grasses and forbs have dried up (Longhurst et al. 1979). However, woody browse does not start growing until later, and grows from April until July (Longhurst et al. 1979). This would explain

why, in the Cyprus samples, the pattern of seasonal variability of digestibility differs between the herb layer (grasses, forbs, and non-graminaceous monocots) and the shrub/tree components of the vegetation. Some of the highest values for *in vitro* dry matter digestibility for the trees and shrubs were in April and June, whereas those of the herb layer were highest from November until February or April.

As the maintainance threshold for digestibility for ruminants is 50%, it seems that the main broadleaved tree species of the Paphos forest were poor quality foods. There were a few exceptions at certain times of year: *Alnus orientalis* which ranged from 53-59% digestibility over the year; *Crataegus* spp. were 50-64% digestible in January, February and April; and *Pistacia terebinthus* was 55-65% digestible in April (Appendix 3). The two conifers, pine and cedar, were of low digestibility all year. Of the two most common *Cistus* species, the less common one, *C. salviifolius*, was of lower digestibility (30-44%) than the more common *C. creticus* (50-60%). The most digestible plants were those in the herb layer: the grasses, forbs, and non-graminaceous monocots (including *Asphodelus*), all of which had their maximum digestibility in the wettest part of the year (November, January, and February). Other studies have also indicated that herb layer plants tend to be more digestible than the leaves of woody species (Drozdz 1979, Hobbs et al. 1981, Torgerson and Pfander 1971) due to the smaller amount of lignin contained in non-browse species (Hobbs et al. 1981).

Maximum digestibility in other non-Mediterranean studies has usually been found to be at the beginning of the growing season; for grasses, the highest digestibilities occurred in May-July (70%) on Hirta (Milner and Gwynne 1974); and dropped during the winter from November to March (Hobbs et al. 1981, Wallmo et al. 1977). Diet digestibility as a whole was highest in May (Schwartz and Ellis 1981, Drozdz 1979) and lowest in January (39%: Drozdz 1979). Often diet digestibility was below 50% in winter during studies of diet quality in non-Mediterranean areas (Drozdz 1979, Hobbs et al. 1983, Wallmo et al. 1977).

Many of the broadleaved trees in Cyprus were likely to contain antiherbivore chemical defences. Oaks are known to contain high tannin levels (Feeny 1970, Mould and Robbins 1981). Condensed tannins were found in *Alnus rubra* which reduced their digestibility to Black-tailed deer *Odocoileus hemionus* (Radwan and Crouch 1974); this was also the case for *Acer* spp.

eaten by elk *Cervus canadensis* (Mould and Robbins 1981), although different *Acer* species contain variable amounts of different tannins (Swain 1979). Oaks, alders and maples were common in the Paphos Forest. Tannins reduce the palatability of herbage to sheep (Wilkins et al. 1953). The ability to perceive "palatability" is a result of natural selection and enables an animal to select for digestible, nutritious or nontoxic foods (Janzen 1979). Tannins reduce the digestibility of almost all soluble proteins by binding to them, forming insoluble copolymers at normal pH (Schwartz and Mautz 1987, Swain 1979, Zucker 1983). They also complex with other natural polymers such as nucleic acids and polysaccharides, rendering them unavailable to the animal. Drying (such as may occur in the summer in Mediterranean climates) may make tannins less extractable from plant matter (Price et al. 1979). However, Robbins et al. (1987a) found that a significant fraction of the tannins in dried plants remained soluble. Soluble phenolics are also considered an important defence against herbivory (Rhoades and Cates 1976). Tannins have been shown to be more effective against grazers than browsers: although plant cell wall digestion was decreased by tannins in domestic sheep (Barry and Manley 1984, Barry et al. 1986), there was no effect on mule deer *Odocoileus hemionus* digestion (Robbins et al. 1987b). If mouflon were like other sheep in their inability to cope well with these compounds, it would be expected that they would avoid plant parts with high concentrations of phenolics.

Conifers contain monoterpenes which can have effects on the digestibility of the food or on its palatability. Bacterial action can be inhibited in deer rumens by volatile monoterpenes (Mabry and Gill 1979). Deer preferences were inversely related to the volatile oil content of junipers, and the monoterpene alcohols in junipers had inhibitory effects on microbial fermentation (Schwartz et al. 1980a,b). However, Elliot (1985), looking at sitka spruce *Picea sitchensis*, lodgepole pine *Pinus contorta* and red deer *Cervus elaphus*, concluded that the levels of monoterpenes in conifers were probably too low to affect either rumen fermentation or food selection. Some monoterpenes can be detoxified in the rumen but this entails an energy cost to the animal (Freeland and Janzen 1974). The conifers in the Cyprus study had low digestibilities, but it is not known whether this was due to the levels of antiherbivore compounds or to the lignin content. In fact, it has been suggested that lignin is in itself an antiherbivore compound in that it reduces digestibility (Janzen 1979, Rhoades 1979).

Plant nitrogen content is highest in the early growing season (Schwartz and Ellis 1981), and as plant structural components (cellulose and other carbohydrates) accumulate in the leaf tissues, the effect is to dilute the nitrogen content of the tissues (Schwartz and Hobbs 1985, Waring and Schlesinger 1985). In Cyprus, the herb layer plants (grasses, forbs, non-graminaceous monocots and *Asphodelus*) all showed a similar pattern of crude protein content over the year, with low values in the dry (non-growing) season and high values in the wet (growing) season. The highest absolute levels of crude protein were found in herb layer plants in the wet season. Hobbs et al. (1981) found that, in Colorado, browse plants tended to have more protein than grasses during the winter (the non-growing season). In Cyprus, in the non-growing season (summer) browse plants had more protein than plants of the herb layer.

Browse plants (trees and shrubs) had the following pattern in Cyprus: highest crude protein levels were in the spring and early summer in most cases, or a slight autumn and winter high (*Cistus* spp. and *Cedrus*). This agrees with the study of Longhurst et al. (1979) on the differences between growth peaks in woody browse plants and in the herb layer in Mediterranean climates. An exception is the *Pistacia* category (which is an amalgam of *P. terebinthus* and *Trifolium clypeatum*, due to the impossibility of distinguishing between them in the faeces analysis: see chapter 4). However the individual records for these two species separately showed similar patterns: high in the winter and dropping during the rest of the year (Appendix 3). Crude protein was highest at 19% in May in sheep diets (Milner and Gwynne 1974, Schwartz and Ellis 1981); and in summer in deer diets (Drozdz and Oseiki 1973: 16-19%, Wallmo et al. 1977). Highest crude protein levels were in the early growing season in Kenya: 8-20% in grasses and 15-30% in forbs (Boutton et al. 1988, Dougall et al. 1964, McKay and Frandsen 1969). Low values were recorded in the winter: 6-7% for sheep diets, and for roe deer *Capreolus capreolus* browse (Drozdz 1979, Hobbs et al. 1983).

Losses of other nutrients can occur by leaching. Potassium is soluble and can be leached out by rain, especially from cells near the leaf surface (Parker 1983, Tukey 1970). Nitrogen and phosphorus are usually in the cell contents (Garten 1978), and can be leached out. Some cell wall solubles of grasses are leached out by rain which does not seem to occur in the highly lignified cell walls of browses (Tukey 1970). Losses of nutrients by leaching follow the order

K>P>N>Ca. Finally, nitrogen and phosphorus are often retranslocated as leaves become senescent (Waring and Schlesinger 1985), which, in the Mediterranean, occurs as the summer drought progresses.

Crude protein and phosphorus have been found to be highly correlated in grassland species but less so in browse species (Holechek et al. 1982a). Both nutrients are associated with amino acid, nucleic acid and protein metabolism in plants (Garten 1978). All nutrients were correlated in February in Cyprus, when the plants were actively growing, and all except phosphorus were correlated in April at the end of the wet season. However, when the different types of plant were examined, all nutrients were correlated all the time only in forbs, and all nutrients except phosphorus were correlated all the time in grasses. As grasses and forbs tended to be more digestible than many of the other plant types, animals eating these would also have been able to ingest high levels of the other nutrients. Because water content and crude protein were correlated each month except June in the plant types in Cyprus, it is possible that mouflon, by eating the most lush plant parts, could have achieved a higher protein intake than by eating less moisture-containing foods. Sheep are known to prefer green to dry forage (Arnold 1964, Arnold and Dudzinski 1978).

There is a connection between protein content of a food and its digestibility for ruminants. Low protein levels suppress microbial activity in the rumen and decrease the cellulose digestibility rate; decreases fibre digestibility, and leads to reduced forage intake (Dietz 1967, Egan and Moir 1965, Elliot and Topps 1963, Hume et al. 1970, Milchunas et al. 1978, Moir and Harris 1962, Provenza and Malechek 1984, Schwartz and Gilchrist 1975, and Van Glyswyck 1970). However if protein is eaten at the same time as poorly digestible food, it increases the digestibility of that food (Hobbs et al. 1981, McCoullough 1979). Therefore, during the summer, when the levels of digestibility of grasses and forbs have dropped, consumption of some broadleaved tree leaves that contain relatively high protein levels may improve the digestibility of otherwise poor forage. Crude protein and digestibility were significantly correlated in several of the plant types analysed from Cyprus, including the forb and grass categories. Many of the other plant types also showed the same trend, although not significantly. If a plant was eaten at all, it would be reasonable to expect it to be eaten when either its protein content was higher than the minimum required for nitrogen balance by sheep; and/or when its digestibility was over 50%.

From April until October the digestibility of broadleaved trees was mostly over 50%, and, in addition, the crude protein content of broadleaves was higher than in any other category during the summer. Therefore mouflon should feed on these plants more from April until October than at other times of the year. The same argument holds for *Teucrium* from November until June; *Rubus* in late winter until June, and *Styrax* from April until June. If there were antiherbivore compounds including toxins in some of these plants, these might render them poisonous or indigestible. *Styrax* was used as a fish poison by the Cypriot villagers, so was possibly not a good food for sheep.

The non-graminaceous monocots and the grasses had low crude protein levels but maintained high digestibility during the summer and might therefore have provided adequate energy sources for mouflon at this time. Grasses and forbs were similarly digestible during the summer but the forbs remained above the 7% crude protein threshold for sheep all year, unlike the grasses which fell below this level in the summer. Therefore mouflon should eat more forbs in the summer than grasses or monocots.

Usually herbage selected by sheep and cattle is higher in phosphorus than that rejected (Plice 1952). Within a single plant species, sheep may select plants with the highest phosphate content (Ozanne and Howes 1971, Reid and Jung 1965) even if the animal is not suffering from phosphate deficiency. Gordon et al. (1954) found that phosphate-deficient sheep and cattle, when offered a phosphate supplement in the form of a ground limestone-phosphate mix, failed to rectify the deficiency. However, this could well be because the animals failed to recognise the supplement as such, it being an unnatural food (Gordon 1970). Mammals also sometimes select for high potassium levels (Heiberg and White 1951, Leigh 1961). Tropical forages are often deficient in mineral elements (McDowall 1985) and it was found that African ungulates tended to concentrate where the forage contained high levels of magnesium, sodium and phosphorus (McNaughton 1988).

The phosphorus levels from the Cyprus plant samples indicate that although during most of the year there were adequate levels in many of the food plants, this was not the case in late summer. When the results for individual species are examined, only a few seemed to contain sufficient (over 0.2%) amounts in August: these were *Vitis vinifera* (0.2%); *Cistus creticus* (0.24%); the leaves of one of the large composites (0.23%); *Poa bulbosa* flower heads (0.28%); and

Bromus sp. flower heads (0.26%). Therefore the mouflon may have suffered phosphorus deficiency during the late summer period. This was also the time when there was low crude protein levels in most food plants except in the broadleaved tree category; and also when digestibility of most food plant types was at the lowest yearly level (Figs 3.1–3.3). As for potassium, it appears that overall levels were above the threshold for sheep requirements all year. Potassium is generally adequate for ruminants in natural vegetation (Everitt and Gonzalez 1981, Gonzalez and Everitt 1982, Milner and Gwynne 1974). It was not known if natural mineral sources such as salt licks existed in the study areas.

Finally, the relationship between availability and the foods eaten must be taken into account. Although some plants might be highly nutritive, if they are rare then it is unlikely they would be very important in the mouflons' diet, if there is other food of reasonable quality and quantity available. The relationship between food available and that ingested was investigated, and is presented in the chapter on Selection. (Chapter 6).

3.5 SUMMARY

1. Grasses, forbs, and non-graminaceous monocots (including *Asphodelus aestivus* had the highest digestibilities during the wet season in Cyprus. Conifers, broadleaved trees, and shrubs were usually less than 50% digestible all year, with the exception of *Teucrium kotschyanum* which was 55–60% digestible all year except late summer/early autumn.
2. The relationship between the low digestibility of the tree species and their probable tannin or monoterpene content is discussed.
3. Crude protein content of the herb layer plants was highest in the wet season in Cyprus. The crude protein content of the other plants (trees and shrubs) was highest in spring and early summer. During late summer, the only plants with more than 7% crude protein were various broadleaved trees. Because these trees were of low digestibility, mouflon may not have found enough digestible protein for maintainance during late summer.
4. The relationship between protein content and digestibility of forage is discussed with reference to the poor summer forage quality. The choices available to mouflon are discussed.
5. Phosphorus content of all the plant types measured fell below 2% only in August. Therefore the mouflon diet may be deficient in phosphorus at this time.
6. Potassium did not appear to be a limiting nutrient at any time of the year.

CHAPTER 4
MOUFLON DIET

4.1 INTRODUCTION

Most wild sheep feed mainly on grasses and forbs, sometimes supplementing their diet with shrubs if the quality or availability of the grazing becomes very low (Blood 1967, Chaudhary 1985, Hoefs 1974, Keating et al. 1985, Oldemayer et al. 1971, Rominger et al. 1988, Schallenberger 1965, Schaller 1977, Shackleton 1985, Shank 1982, Stelfox 1976, Tilton and Willard 1981). Domestic and feral sheep also feed mainly on grasses and forbs, but will take shrubs if necessary (Alexander et al. 1983, Arnold and Dudzinski 1978, Bullock 1985, Milner and Gwynne 1974, Squires 1980). However, most sheep other than mouflon do not live in forest, but in open steppe or low scrub country, and actively avoid forest (Geist 1971, Petocz 1978, Schaller 1977). Only the mouflon living in Corsica and Sardinia live in forest, and in fact shrubs were thought to be an important part of their diet in Corsica (Pfeffer 1967).

Cyprus is thought to have been completely forested at the time of the mouflons' introduction 8000 years ago (Wertime 1982) so the animals would have had to adapt to this new habitat type. Cyprus mouflon are small wild sheep, (40-50kg), similar in size to those in Corsica, Armenia and the Punjab (Schaller 1977) and therefore have relatively narrower mouths than the larger argalis *Ovis ammon* or American-type sheep. Narrow mouths are known to facilitate selectivity of plant parts such as shoots and buds of trees and shrubs (Gordon and Illius 1988, Janis and Ehrhardt 1988 , Jarman 1974). It might be expected that the Cyprus mouflon would be able to take advantage of the browse available in the forest. This would, however, also depend on their ability to cope with the tannins often found in the genera of trees available in the Paphos forest (Chapter 3). To find out whether the Cyprus mouflon had retained the grazing habits of their relatives on the mainland, or whether they had turned to utilising some of the browse available in their new forest habitat, a quantitative analysis of their diet was necessary.

Analysis of herbivore diets may be carried out using several methods. These are well reviewed in Schwartz and Hobbs (1985). They include:

- Direct observation of the animals either from a distance (in the case of wild

animals) or from close quarters, using tame animals;
- Oesophageally fistulated animals (where the animals are tame and can be regularly visited to collect samples).
- Analysis of stomach contents by regularly slaughtering and examining animals from the study population;
- Faeces analysis–estimating quantitatively the components of the animals' diet.

Direct observation is very useful when tame animals are used, and can provide quantitative results (Belovsky 1981, Kossak 1983). However, because wild animals must usually be observed from a distance, attempts at quantifying results can be highly biased (Wallmo et al. 1973). Where animals are endangered and cannot be slaughtered, faeces analysis is often the best method of diet examination (Kessler et al 1981). The same applies when there cannot be disturbance of the study population (Milner and Gwynne 1974, Schwartz and Hobbs 1985) or where the animal is secretive (Kessler et al. 1981). In general, faeces analysis is useful when a wild population is being examined (Putman 1984, Vavra et al. 1978) and especially where the individuals all live in the same range and where relative values are of interest (Vavra et al. 1978). In the case of the Cyprus mouflon, they could not be fistulated, being wild, or slaughtered, as they are an endangered species. It was difficult to observe them feeding, due to their timidity, the nature of the habitat (forested, deeply dissected, broken terrain), and the impossibility of collecting quantitative feeding data during the hours of darkness. Therefore faecal analysis was chosen to analyse the mouflons' diet in this study.

Faeces analysis has been shown to be equivalent to rumen content analysis by Todd and Hansen (1973) for bighorn sheep *Ovis canadensis* ; and by Kessler et al. (1981) for pronghorn antelopes *Antilocapra americana*. Vavra et al (1978) found no differences between analysis of oesophageal and faecal material from cattle. McInnis et al. (1973) found that for ranking plant species important to a herbivore, faecal, oesophageal, and rumen content analysis all gave similar results.

4.2 METHODS

4.2.1 PLANT EPIDERMIS REFERENCE COLLECTION

The epidermis of plant leaves is composed of cutin, which is indigestible. Therefore a method has been evolved to take advantage of this fact in the identification of plant species in animals' diets by faeces analysis. Many groups, genera, and even some species of plants can be identified by their epidermal characteristics using a combination of such factors as cell size and shape, configuration of stomata, hairs or trichomes (stellate bodies) and silica particles.

The same plant samples that were collected for the nutrient content analysis (Chapter 3) were used for making up the reference collection . Portions of the milled plant samples were taken, placed in glass vials, and commercial bleach added for 3-5 minutes or until the samples had lost their colour. Grasses needed very little time compared to the dark, tough broadleaved tree leaves. They were then placed in a 0.2mm sieve and washed with water to remove the bleach and very small particles. A metal screen with holes 6mm in diameter was then placed across two slides, and the holes filled with the sample, one hole per slide. The screen was then removed and the sample spread out evenly. The samples were mounted in 'Hydromount', a commercial mounting fluid, and a coverslip placed on each. The slides were labelled and used as a reference library for later identification of plant epidermal fragments that were seen in faeces analysis. Black and white microphotographs were then taken of epidermal fragments of each species. These photos were used as an aid to identification as well as the reference slides themselves.

4.2.2 FAECES ANALYSIS

The most widely used faeces analysis method are variations on that outlined by Sparks and Malechek (1968). They calculated that the dry weight intake of a plant species was related to the percent frequency of that species estimated in the faeces of a herbivore. This has since been tested and upheld (Holechek and Gross 1980, 1982, Holechek et al. 1982b; Johnson and Pearson 1981; Todd and Hansen 1973; and Vavra and Holechek 1980). For this to be correctly calculated, however, three main factors must be taken into account. First, the fragment sizes of plant epidermis must be fairly uniform, which can

be effected by grinding the dried samples through a 1mm screen and then washing it over a 0.125mm or 0.2mm sieve. (Easterbee 1981, Johnson and Wofford 1983). The species should all be equally identifiable, so epidermal fragments must be cleared. This may be ~~be~~ done with household bleach (Barker 1986a and 1986b, Bullock 1985, Chaudhary 1985, Hansen et al. 1978, Johnson and Woofford 1983, Putman 1984). Finally, it must either be assumed that all plant species or groups are digested equally, or correction factors must be applied (Dearden et al. 1975, Fitzgerald and Waddington 1979, Putman 1984, Schwartz and Hobbs 1985).

4.2.3 Accuracy of faeces analysis

Overall accuracy of the method outlined above has been shown to be good (Dearden et al. 1975) unless a large part of the diet is composed of stemmy shrub material (Holechek and Valdez 1985). The method is most accurate for plants comprising 20% by dry weight or more of the diet (Holechek and Vavra 1981). It is good for grasses but can over or underestimate forb and shrub material (Gill et al. 1983). Barker (1986a) warned that accuracy was poor if a fragment count method was used rather than the frequency conversion method and suggested instead that only four categories were used per species/plant group: none, a little, some, or a lot. (Barker 1986b).

Fresh droppings were collected regularly throughout the study period. Areas near the vegetation survey plots were cleared of droppings, and when the area was revisited, any fresh droppings were collected and the less fresh ones scattered and covered with dust. This avoided the possibility of collecting old faeces by mistake. In the dry season droppings dried out very quickly and fresh ones could be recognised by their softness, dampness, light brown colour when broken, and by their mucus sheen. They were usually in discrete piles, having not been scattered by the passage of other mouflon, whereas the older ones were often scattered or half-buried under litter, or loose soil. Older ones were dusty and desiccated. In the winter older droppings soon became mouldy, and fresh ones were distinguished by their colour when broken and by the mucus sheen. The droppings were commonly found along their paths (mouflon, like domestic sheep, habitually use the same paths) and in the scrapes they make when resting. The faeces were stored in 10% formaldehyde solution in plastic vials, and labelled with date and site.

Most workers have used Sparks' and Malechek's method thus: they have mounted equal amounts of the dried milled samples on five microscope slides per sample, and examined 20 microscope fields at between 100x and 150x magnification per slide; counted the number of fields examined in which each species appeared and used a frequency conversion to get the percent of each species composing each sample (Bullock 1985, Dearden et al. 1975, Gill et al. 1983, Hansen and Lucich 1980, Holechek and Gross 1980, 1982, Holechek and Vavra 1981, Johnson and Woofford 1983, Kessler et al. 1981, Rowland et al. 1983, Tilton and Willard 1981 and Todd and Hansen 1973).

The faeces collected in Cyprus were washed with tap water to remove the formaldehyde and dried at 40°C for 24 hrs. One pellet from each sample was then taken and used to produce composite samples which were then milled through a 1mm screen in a Retsch centrifugal mill. At least ten pellets, each one from a separate defecation, were used for each composite sample. Each sample represented the faeces collected by month and by watershed, which were Pia, Vroisha, Ayia, Ayios Mercurios, and Limnitis. (Fig 1.2) There were months in which faeces were not collected: October is missing for Vroisha and Ayia; January, May and July are missing for Pia, faeces from Ayios Mercurios were only collected in April, May, June and September, and from Limnitis in May, June and August. This was due to Limnitis and Ayios Mercurios being difficult to travel to and they were abandoned as study areas after an initial period.

The milled samples were then soaked in commercial bleach until they turned a straw colour, washed through a 0.2mm sieve, and were then dried at 40°C for 12 hours. Five slides were then made for each sample, using a metal template as in the plant reference collection. The material was then spread out evenly, mounted in 'Histomount', a commercial permanent mounting medium, and a coverslip added. Each slide was labelled with date and site, underneath the slide, so they could not be read while the slides were being looked at. The slides were then shuffled so that they would be examined 'blind'. Twenty microscope fields per slide were examined at 150x magnification, making 100 fields examined per sample. The presence or absence of each recognisable species or plant category was recorded for each field. Percentage frequency of occurrence of each species or plant category was then calculated for each sample. About three fragments per field were observed.

4.3 RESULTS

Seventeen different types of epidermally distinguishable plant species or categories were found in the reference collection. Of these, eleven distinct classes of epidermal fragments could be distinguished in the faeces. These ranged from wide plant groups such as 'grass' or 'forbs' to narrower generic or specific ones such as *'Cistus sp.'* or *'Teucrium kotschyanum'*. The types recognisable in the reference collection and in the faeces are presented in Table 4.1. The percentage frequency of a plant in the faeces was taken as use of that plant by the mouflon. The percent frequency of each food type by valley and by month are presented in Appendix 5; the means across valleys and the standard errors are in Fig 4.1a and Table 4.2. Fig 4.1b shows the amount of each plant type in the faeces by valley. A Spearmans rank correlation was done to compare the seasonal patterns of occurrence of each type of food in the faeces between Vroisha and Ayia, Pia and Ayia, and Pia and Vroisha, these being the valleys in which year-round data was collected. This gave an idea of how the diet of mouflon varied in different valleys.(Table 4.3)

4.3.1 Grasses

The mean percent of grass use (Fig 4.1a) varied between 15-27%, with the exception of early summer when levels dropped to 9-13%. October was represented by only one valley (Pia) which had higher levels of grass in the diet during winter than in the other valleys. Ayia, Pia and Vroisha were not correlated in the pattern of grass use over the year. In Vroisha, grasses comprised about 20% of the diet all year, with the lowest levels being in early summer. Ayia valley had lower and more fluctuating levels of grass use than Vroisha. The lowest values in Pia were in summer, but there were higher levels in Pia than Ayia or Vroisha in autumn, winter and early spring (20-55%). Early spring and summer values were lower than late summer ones in Ayios Mercurios. Limnitis had levels of 8-17% in the summer months. The least grass was eaten in June in all valleys except Ayios Mercurios (Fig 4.2).

4.3.2 Forbs

Mouflon showed higher mean use (over 25%) of forbs in spring and summer than in late autumn and winter (November-February) when percentage frequencies were 16-22% (Fig 4.1a). Use was highest in the late spring and

TABLE 4.1

The seventeen recognisable epidermis types and whether they were found in the faeces (+).

Found in Faeces	TYPE
+	All grass species
+	All species of *Cistus*
+	*Lithodora hispidula*
+	All broadleaved trees except those specifically mentioned below
+	*Pinus brutia*
+	*Rubus sanctus*
+	All forbs except those in this list under another name
+	All monocotyledons except grasses and *Asphodelus aestivus*
+	*Teucrium kotschyanum*
+	*Pistachia terebinthus* and *Trifolium clypeatum*
+	*Asphodelus aestivus*
	Styrax officinalis
	Cedrus libani ssp brevifolia
	Platanus orientalis
	Quercus alnifolia
	Myrtus communis
	Astragalus lusitanicus

Table 4.2

PERCENT OF DIFFERENT FOODS IN FAECES FROM ALL THE VALLEYS COMBINED ($\bar{x}$ and Std.Err.)

MONTH	ASPHODEL	BROADLEAF	CISTUS	FORBS	Pistacia/Trilol	GRASSES
JAN	5.18 ±2.94	8.17 ±1.53	13.81 ±5.37	14.58 ±3.54	5.15 ±2.96	19.77 ±0.23
FEB	4.17 ±3.20	4.08 ±2.71	15.21 ±7.75	20.78 ±3.77	5.20 ±1.42	16.96 ±4.60
MAR	1.62 ±0.82	2.90 ±2.23	12.26 ±5.94	25.01 ±4.13	3.60 ±2.11	16.39 ±2.50
APR	1.47 ±0.95	3.89 ±1.32	4.75 ±2.47	27.01 ±3.52	4.26 ±1.12	26.23 ±9.73
MAY	1.60 ±0.67	3.74 ±0.83	3.36 ±2.77	39.68 ±2.90	2.00 ±0.49	13.32 ±1.68
JUN	2.67 ±1.24	13.91 ±3.34	0.60 ±0.37	32.03 ±3.26	9.08 ±2.10	9.23 ±1.54
JUL	7.10 ±0.51	6.93 ±1.85	4.68 ±3.57	28.73 ±4.60	11.12 ±3.80	19.10 ±3.23
AUG	9.63 ±2.38	13.90 ±2.09	3.38 ±1.94	25.44 ±1.59	5.00 ±0.85	15.28 ±2.65
SEP	8.92 ±3.60	12.20 ±2.45	1.25 ±0.53	26.78 ±2.95	9.03 ±2.25	17.34 ±3.83
OCT	0 0	8.47 0	0.40 0	30.65 0	4.03 0	27.82 0
NOV	12.08 ±6.29	11.85 ±4.05	2.65 ±1.20	16.02 ±2.60	7.15 ±1.29	20.00 ±1.61
DEC	7.38 ±3.27	12.93 ±4.58	4.59 ±2.63	21.83 ±1.90	6.58 ±2.52	17.73 ±3.14

MONTH	LITHODORA	MONOCOT	PINUS	RUBUS	TEUCRIUM
JAN	10.60 ±0.64	7.40 ±6.70	2.47 ±2.10	0 0	13.02 ±10.21
FEB	10.18 ±2.01	10.68 ±6.09	2.07 ±1.20	0.34 ±0.34	10.16 ±5.51
MAR	10.40 ±3.05	12.60 ±6.22	2.97 ±1.84	3.52 ±2.85	8.73 ±3.85
APR	8.15 ±3.56	14.48 ±7.51	2.57 ±1.32	0.30 ±0.21	6.44 ±5.14
MAY	2.73 ±1.21	30.28 ±3.78	1.38 ±0.72	0 0	1.89 ±0.93
JUN	1.55 ±0.64	26.84 ±2.62	1.00 ±0.67	0.55 ±0.55	2.46 ±1.02
JUL	5.97 ±0.26	12.60 ±0.46	0.84 ±0.11	0 0	2.59 ±1.85
AUG	4.36 ±1.66	18.08 ±2.66	1.61 ±0.65	0 0	3.31 ±2.64
SEP	3.72 ±2.08	18.40 ±1.61	1.20 ±1.09	0.10 ±0.10	1.06 ±0.59
OCT	15.32 0	12.50 0	0 0	0 0	0.40 0
NOV	11.44 ±2.59	13.22 ±1.46	0.38 ±0.24	0.09 ±0.09	5.47 ±1.92
DEC	13.24 ±1.74	8.52 ±0.91	0.86 ±0.24	0 0	6.47 ±1.97

Table 4.3

Spearmans Rho values for between-valley comparison of food type patterns.

Type	Vroisha-Ayia (N=11)	Vroisha-Pia. (N=8)	Ayia-Pia (N=8)
Grasses	0.291	0.315	0.471
Cistus spp.	0.770 **	-0.309	-0.239
Lithodora hispidula	0.518	0.321	0.727 *
Broadleaved trees	0.482	0.652	0.876 **
Pinus brutia	-0.255	-0.178	-0.385
Rubus sanctus	-0.191	-0.216	0.175
Forbs	0.691 *	0.718 *	-0.045
Non-grass Monocots	0.636 *	0.043	-0.101
Teucrium kotschyanum	0.465	0.315	0.427
T.clypeatum/P.terebinthus	0.436	0.063	-0.211
Asphodelus aestivus	0.618 *	0.856 *	0.903 **

*=p<0.05; **=P<0.01

Fig 4.1A

PERCENT OF DIFFERENT FOODS IN FAECES FROM ALL THE VALLEYS COMBINED. ($\bar{x}$ and Std. Err.).

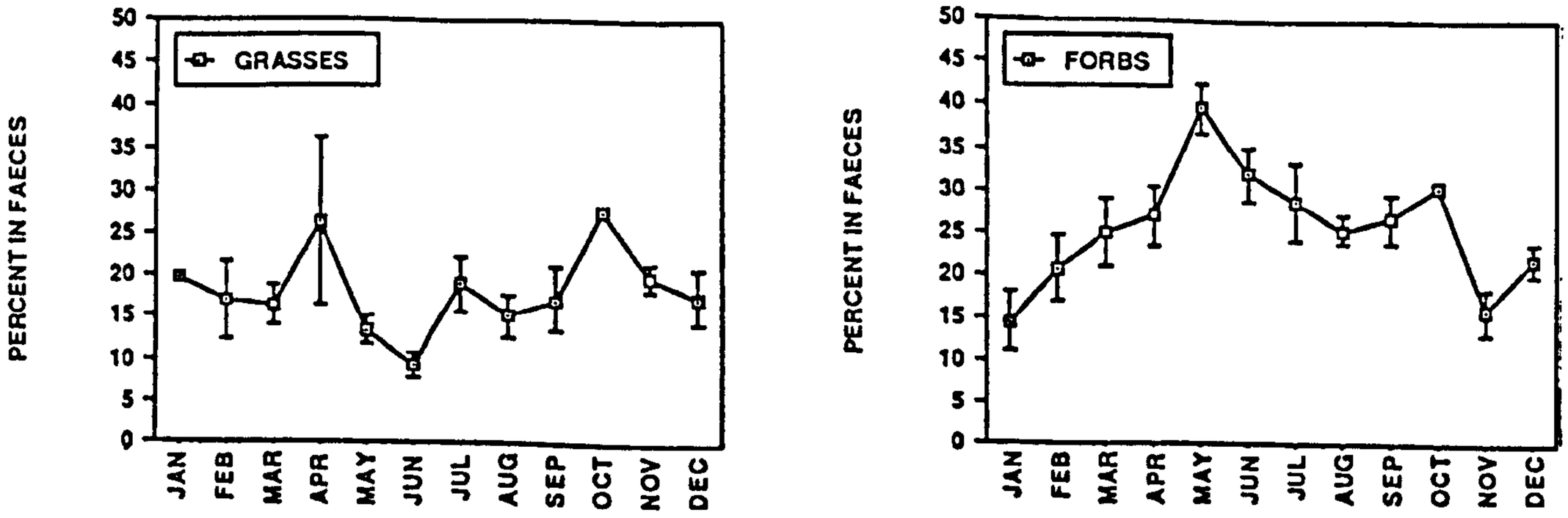
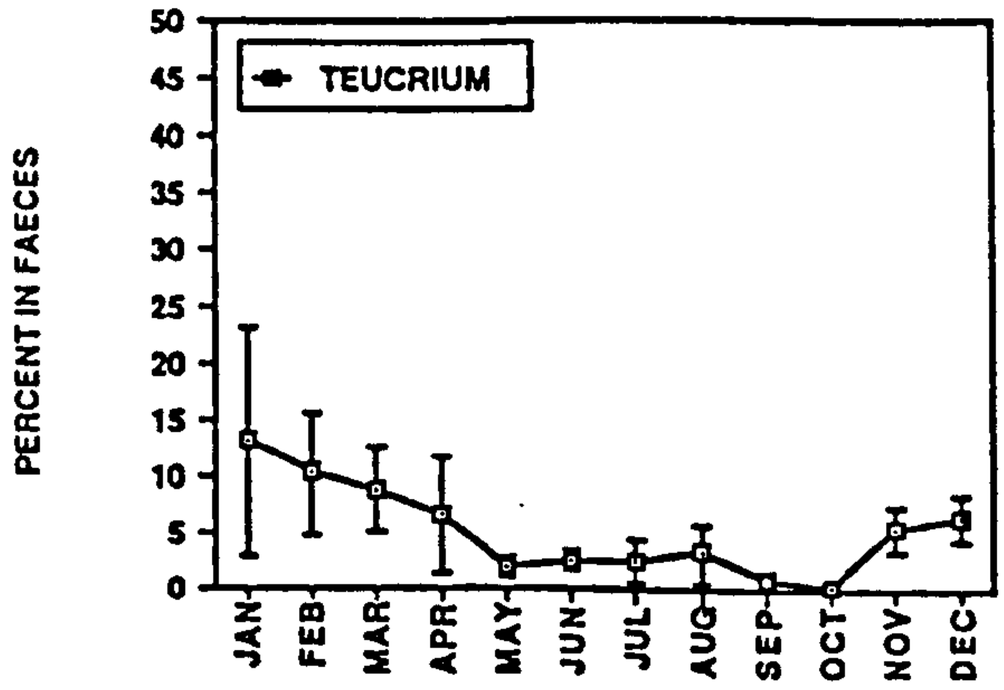
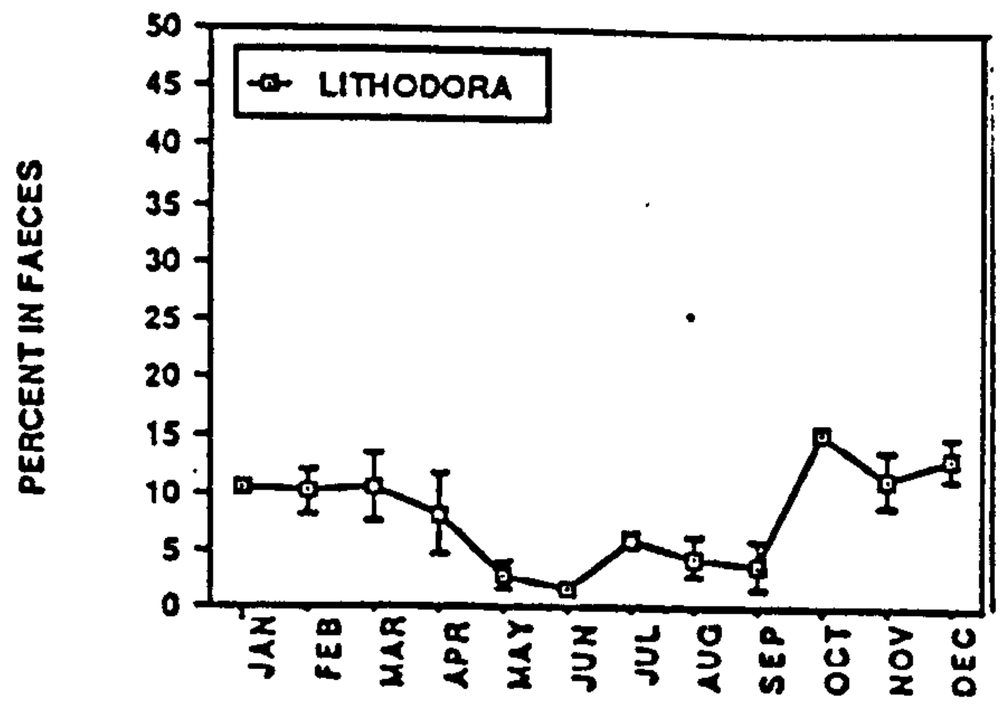
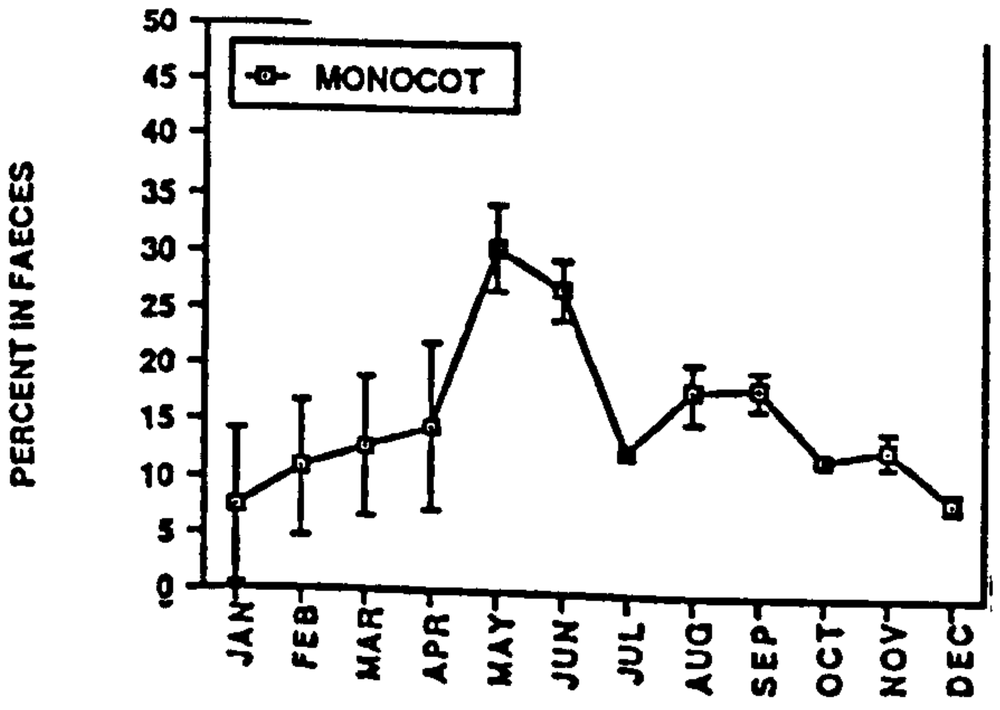


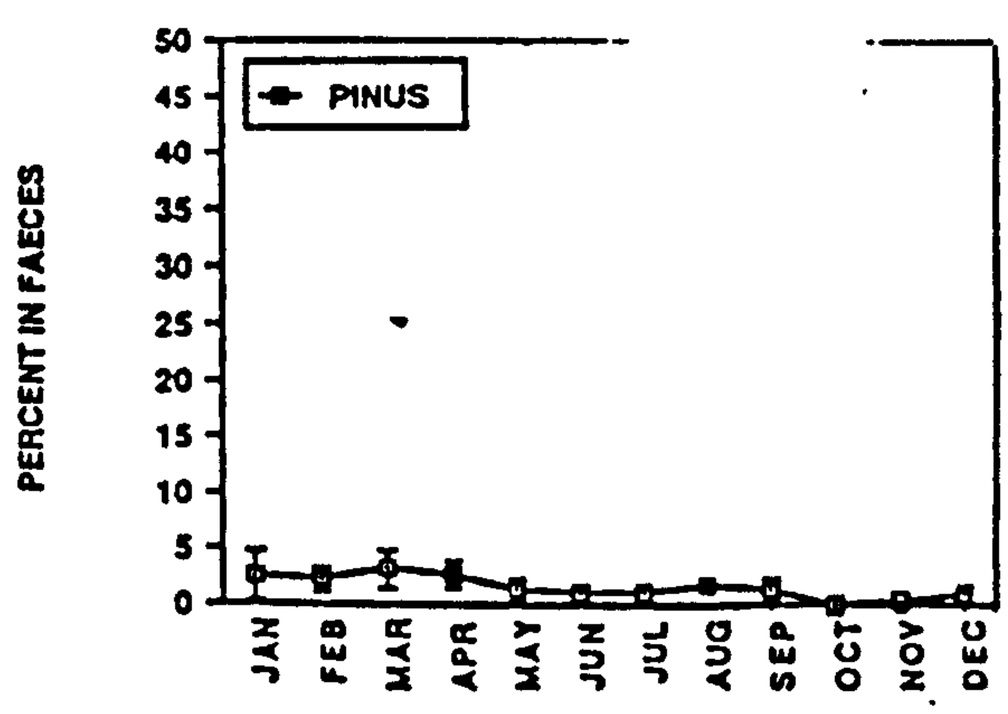
Fig 4.1 A

PERCENT OF DIFFERENT FOODS IN FAECES FROM ALL THE VALLEYS COMBINED (Cont.)









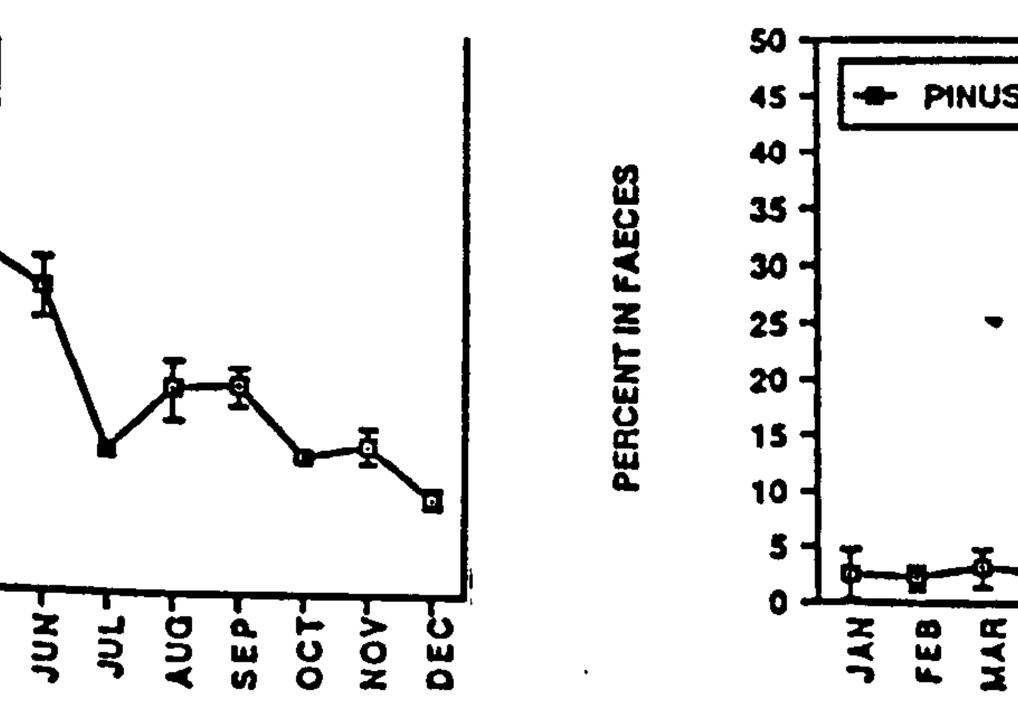
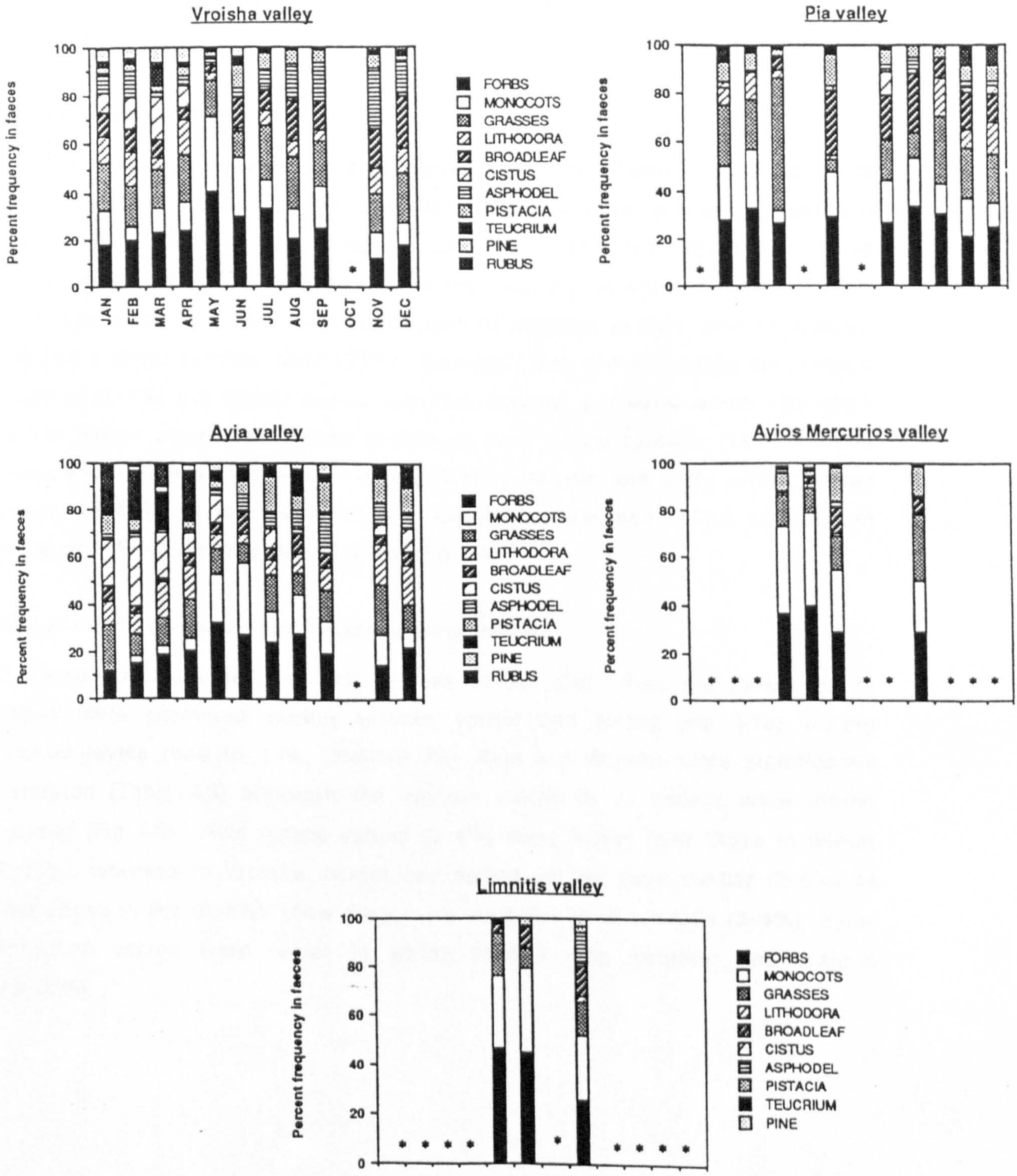


Fig 4.1 B

Percent frequency of different plant groups found in the faeces in the different valleys throughout the year. MONOCOTS=non-graminaceous monocotyledons; LITHODORA=*Lithodora hispidula*; BROADLEAf=broadleaved trees; CISTUS=*Cistus* spp.; ASPHODEL=*Asphodelus aestivus*; PISTACIA=*Pistacia terebinthus* and *Trifolium clypeatum*; TEUCRIUM=*Teucrium kotschyanum*; PINE=*Pinus brutia*; RUBUS=*Rubus sanctus*. No data=*



summer, especially in May, when the value was 39.7%. Separate valleys differed slightly (Fig 4.3). Vroisha and Ayia were very similar in both the pattern and magnitude of values ($P<0.05$). They showed autumn and winter levels of 11–22%, and summer values of 20–40%. Vroisha and Pia were also correlated ($P<0.05$). The same pattern was seen in Ayios Mercurios and Limnitis valleys for the months sampled. In all cases May was the month when there was most forb use (32–46%). In Pia valley there was a smaller annual range than in Ayia or Vroisha.

4.3.3 Broadleaved trees

Mean percent frequency of broadleaved tree use ranged from 3–14% (Fig 4.1a). From late winter until the beginning of the summer percent frequencies were below 10% and then rose in June to 13.9%. Thereafter the values fluctuated around 7–13% for the rest of the year. Pia resembled Ayia ($P<0.01$). There was much less broadleaf in the diet of mouflon in Ayia than in Vroisha. Ayia had a slight summer peak (10%). Broadleaf tree use in Vroisha was lowest in spring (3–7%) but higher during summer, autumn and early winter (10–21%). Pia had higher values than either Vroisha or Ayia during summer (18–27%); late winter and spring values were between 0–6%; autumn and early winter values between 8–16%. Ayios Mercurios and Limnitis valleys had values of 2–4% in spring and 8–13% during the summer (Fig 4.4).

4.3.4 *Trifolium clypeatum* and *Pistacia terebinthus*.

These species comprised 8% or less of the diet when the means of all valleys were examined, during autumn, winter and spring (Fig 4.1a). During summer levels rose to 11%. Neither Pia, Ayia nor Vroisha were significantly correlated (Table 4.3) although the highest values in all valleys were during summer (Fig 4.5). Ayia spring values (0–4%) were lower than those in winter (5–11%), whereas in Vroisha, winter and spring values were similar (2–5%) as were those in Pia (6–8%). Few fragments were found in Limnitis (0–4%). Ayios Mercurios values were lower in spring (2–8%) than summer and autumn (12–15%).

4.3.5 *Cistus* spp.

Mean percentage frequencies for *Cistus spp* were highest in late winter and early spring (12-15%). During the rest of the year values were 5% or less (Fig 4.1a). Ayia and Vroisha were very similar ($P<0.01$) in the pattern of *Cistus* use (Fig 4.6), where high values were only found in winter and in spring. In Pia, *Cistus* spp. comprised 3% or less of the faeces all year except in one month (August: 9.2%). Ayios Mercurios and Limnitis had very little *Cistus* recorded (0.5-1.3%) at any time.

4.3.6 *Asphodelus aestivus*

Use of Asphodelus was between 1-6% from January until June when the mean percent frequencies were examined. From then until the end of the year values were higher: from 7-12%. (Fig 4.1a). October was only measured from Pia and no fragments at all were found in that month in that valley. Vroisha and Ayia were similar ($P<0.05$) in the seasonal pattern of *Asphodelus* use (Fig 4.7). Both valleys had their highest values from late summer to autumn. Vroisha had higher values in late winter than in spring, whereas in Ayia values were more uniform during these seasons. Pia was similar both to Ayia ($P<0.01$) and to Vroisha ($P<0.05$) in that the highest values were from late summer to early winter. No fragments were found from Pia during the rest of the year. Spring and early summer values in Limnitis were lower than the late summer ones. Ayios Mercurios had very low values at any time (below 3%).

4.3.7 *Teucrium kotschyanum*

Mean percent frequencies of use of this species were both higher (7-13%) and more variable in the winter and early spring than in the summer and autumn (0-6%)(Fig 4.1a). Pia, Ayia and Vroisha were not correlated (Table 4.3). Vroisha had values below 4% all year except in March when 9% was found in the faeces. Ayia had much higher values in winter and early spring when levels were between 8-18%. Summer values were lower; between 2-5% with the exception of August (11%). Autumn values were below 6%. Pia also had higher winter values (6-8%) than during the rest of the year (0-2%). Ayios Mercurios and Limnitis valleys had very low values in all months measured (0-1.6%) (Fig 4.8).

4.3.8 *Lithodora hispidula*

Mean autumn, winter, and early spring values were higher (10–16%) than in late spring and summer (1–9%) (Fig 4.1a). Pia and Ayia were similar ($P<0.05$). They both had higher values in autumn, winter and early spring than in the summer (Fig 4.9). This was also true of Vroisha but the spring values tended to be lower and more variable. Very little *Lithodora* was ever found in faeces from Ayios Mercurios or Limnitis.

4.3.9 Non-grass monocotyledons

Late spring and early summer mean values were higher (23–31%) than during the other seasons(Fig 4.1a). Late summer, autumn and winter levels were between 8–19%. Vroisha and Ayia were correlated ($P<0.05$) with a peak in values in the late spring and early summer (20–32%). Ayios Mercurios and Limnitis also had high values at this time (25–35%). Values did not fluctuate widely in Pia valley, although a late spring (April) value (4.8%) was much lower than the rest of the year (9–25%) (Fig 4.10).

4.3.10 *Pinus brutia*

This was an uncommon item in the diet (less than 3% of the mean values) (Fig 4.1a). Valleys differed in the proportion of pine use over the seasons (Fig 4.11). Pia, Limnitis and Ayios Mercurios had very little at any time of year (less than 3%.) Vroisha had more pine in the late winter and in the spring than at other seasons. Ayia had more in the spring and late summer than during the rest of the year.

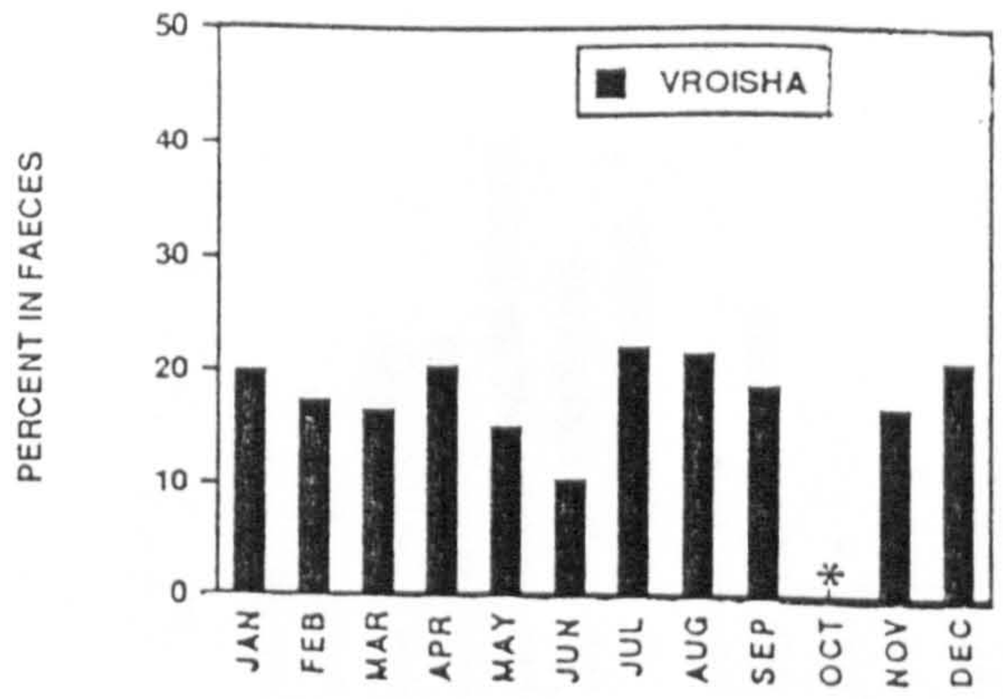
4.3.11 *Rubus sanctus*

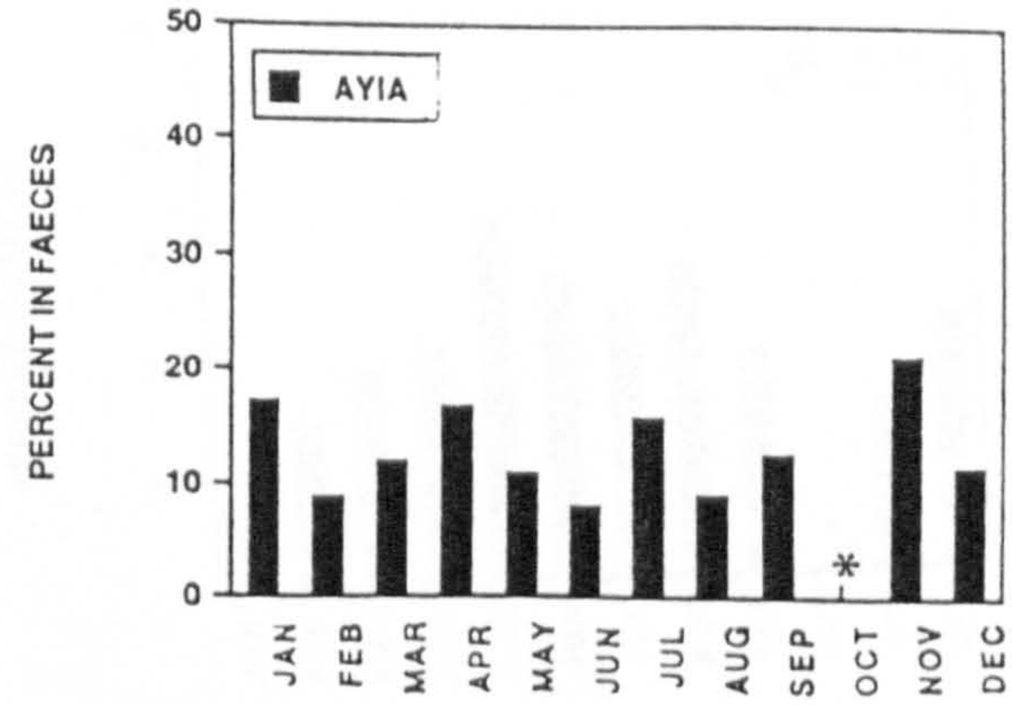
This was rarely found in the faeces at any time (Fig 4.1a). Fragments were unusual and never comprised more than 3% of the faeces at any time except in Ayia valley in March (9.2%) (Fig 4.12). None was ever found in Limnitis valley, only 0.27% in November in Vroisha, less than 1% in Ayios Mercurios, and only in March and June in Pia (1.4 and 2.7%).

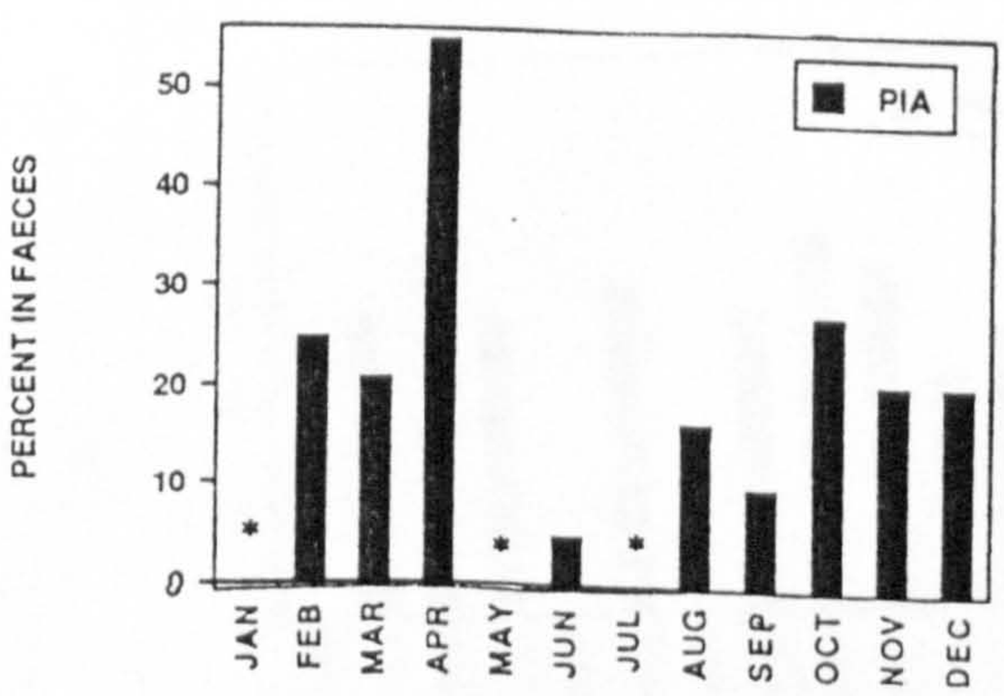
Fig 4.2

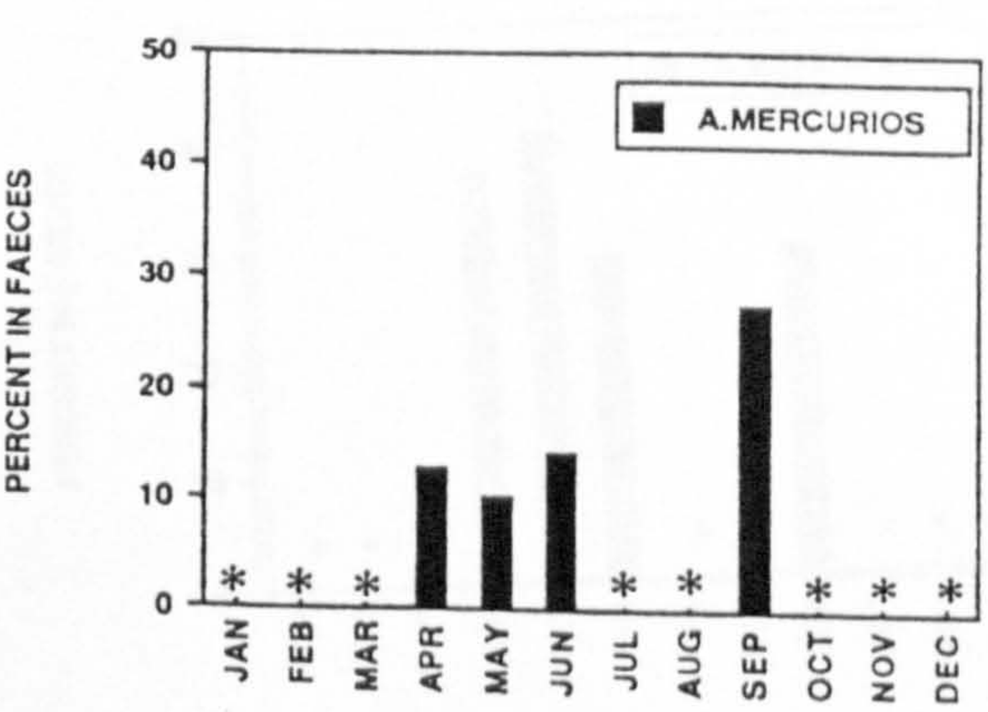
Percent frequency of grasses in the faeces.

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS AND LIMNITIS.
No data=*









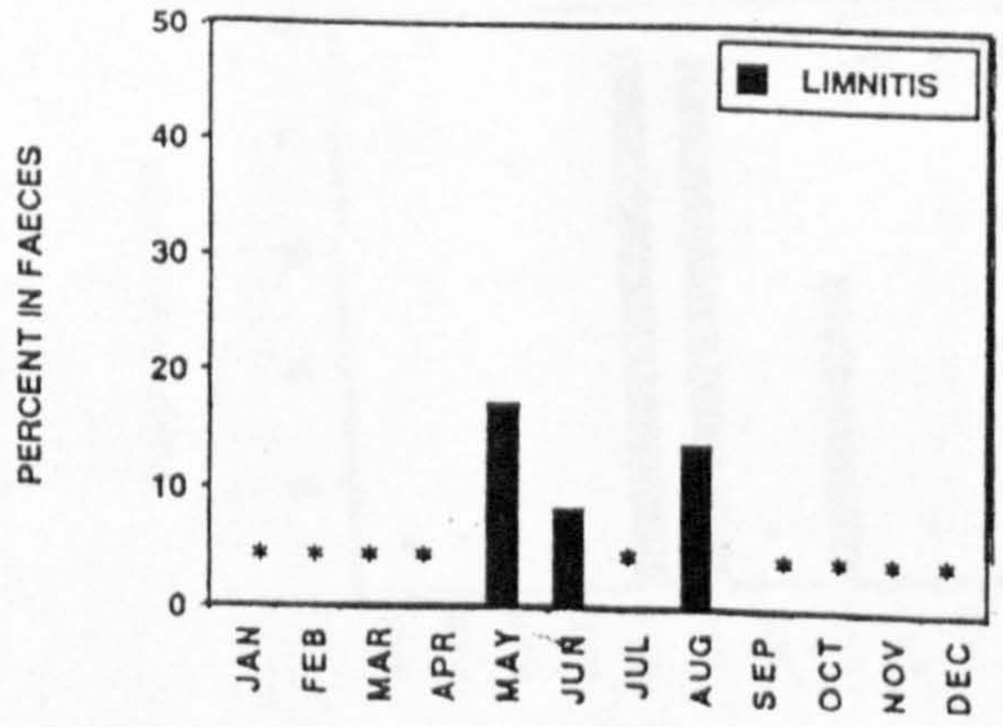


Fig 4.3

Percent frequency of forbs in the faeces.

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS AND LIMNITIS.
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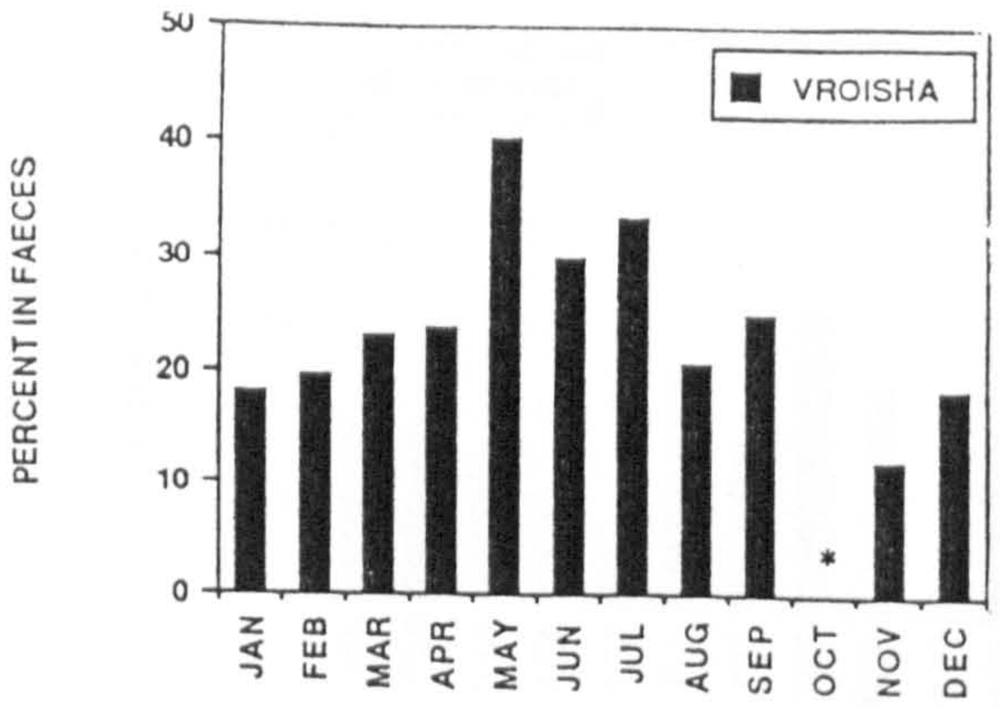
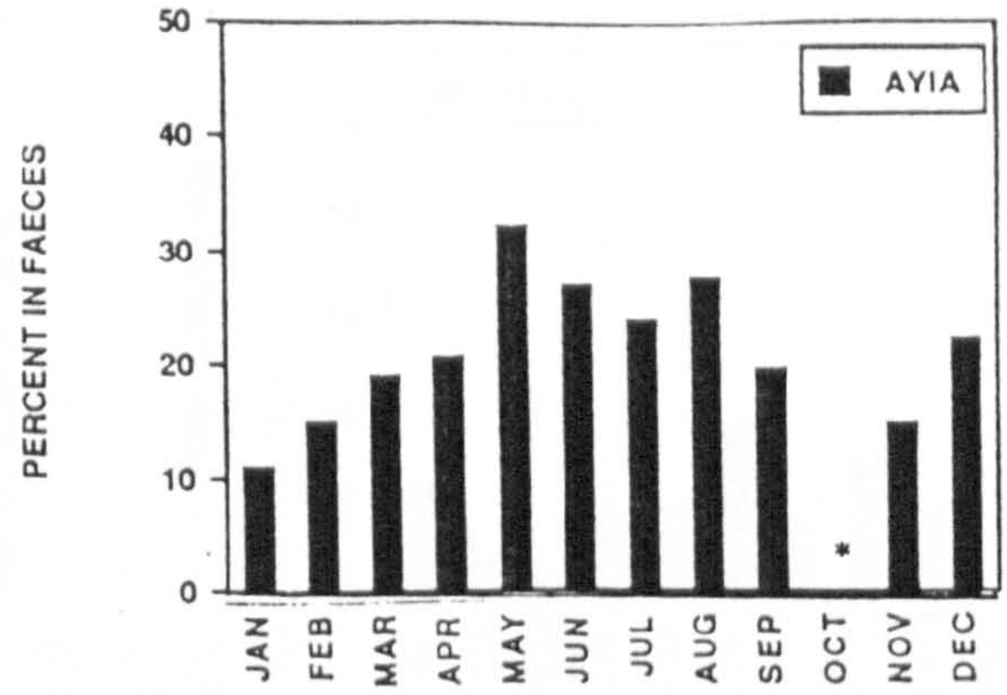
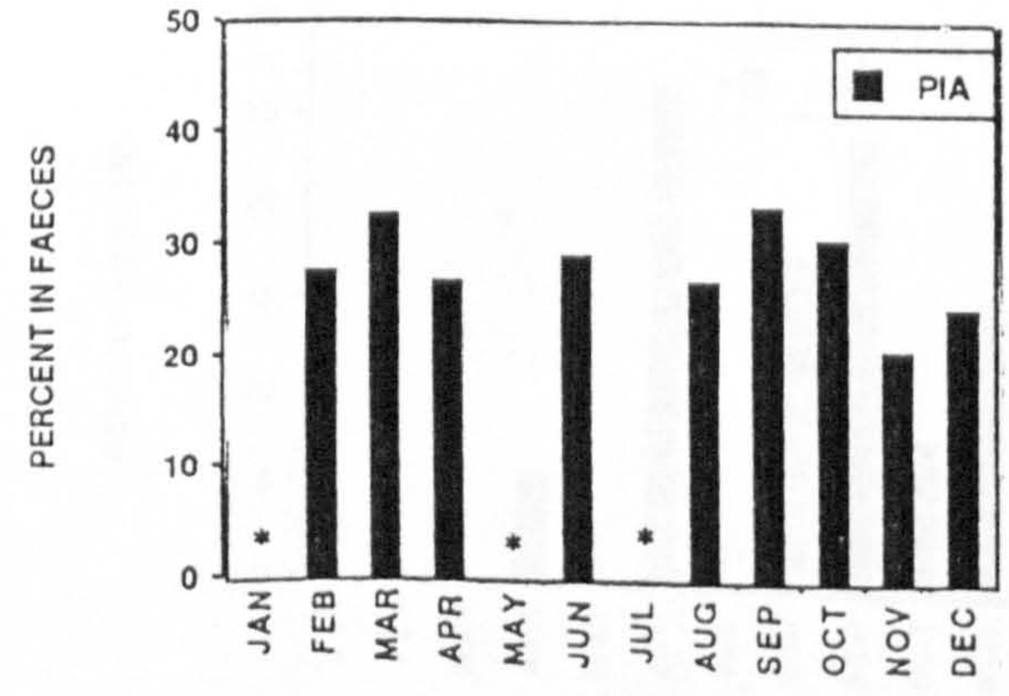
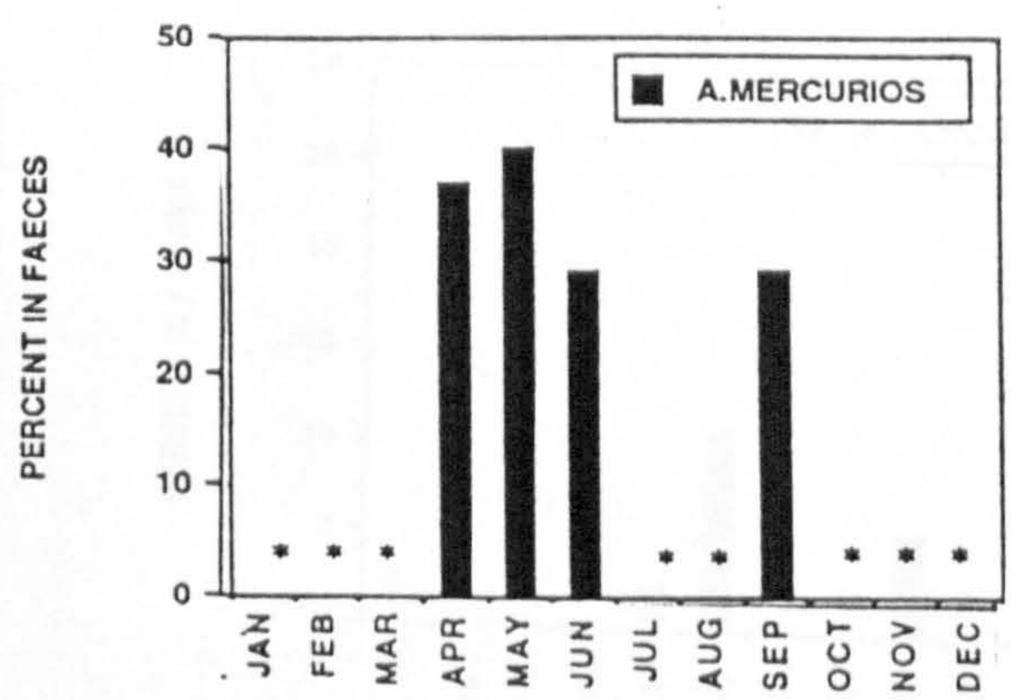








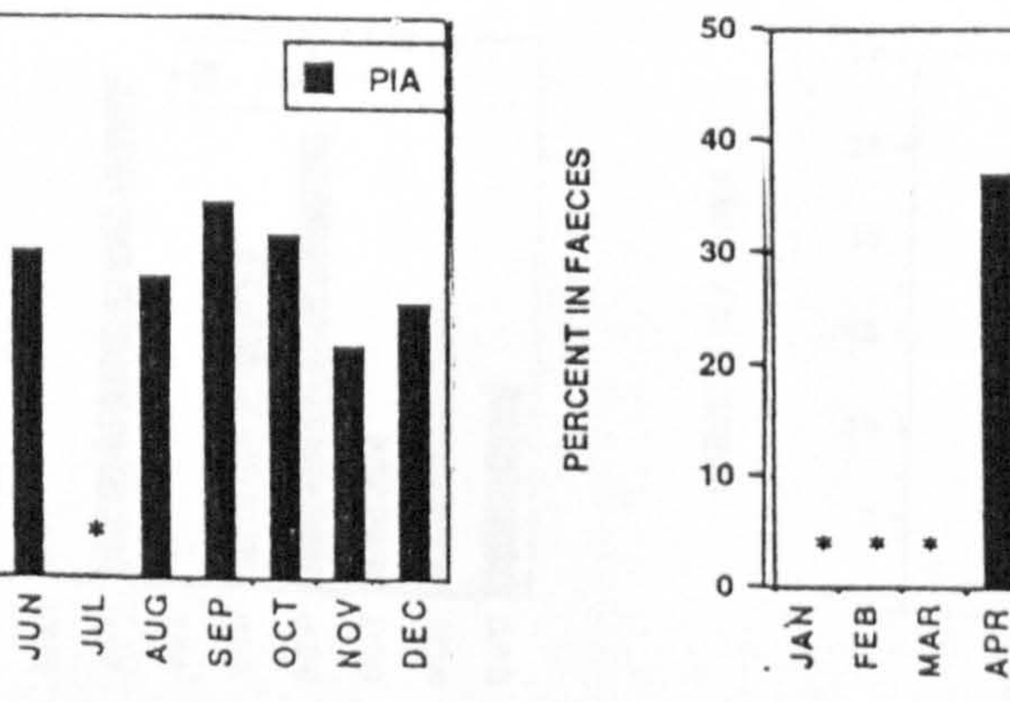
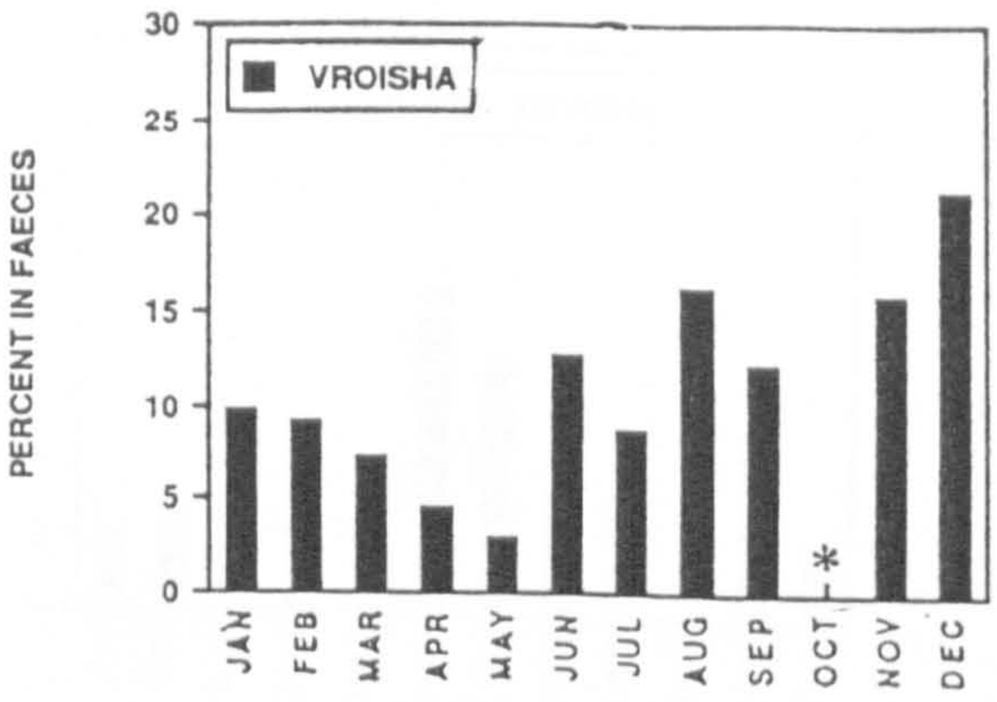


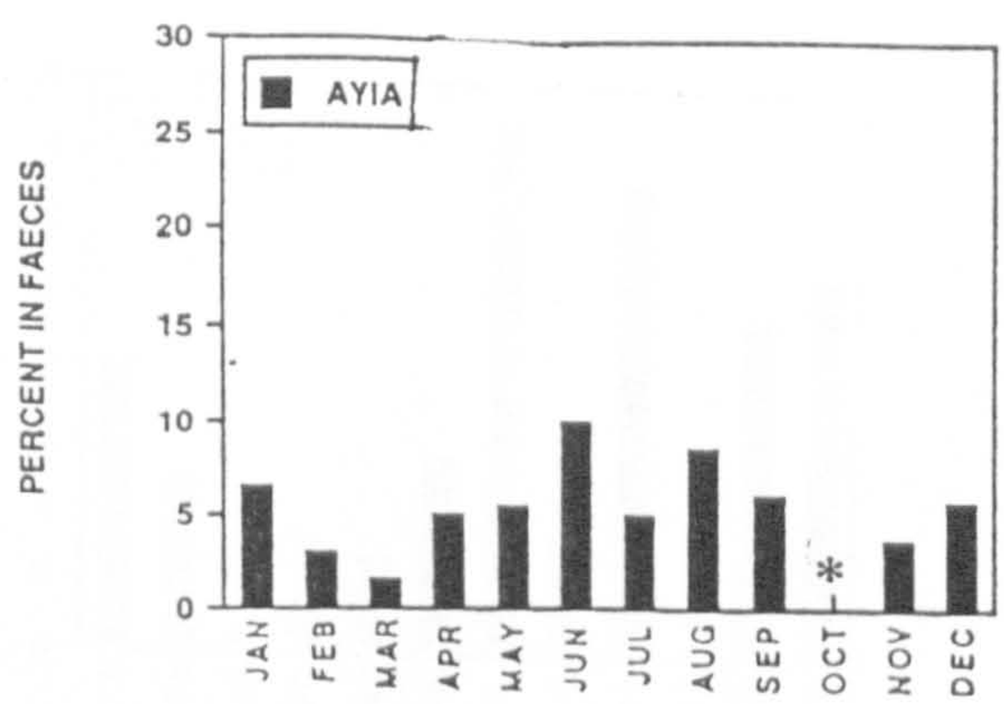
Fig 4.4

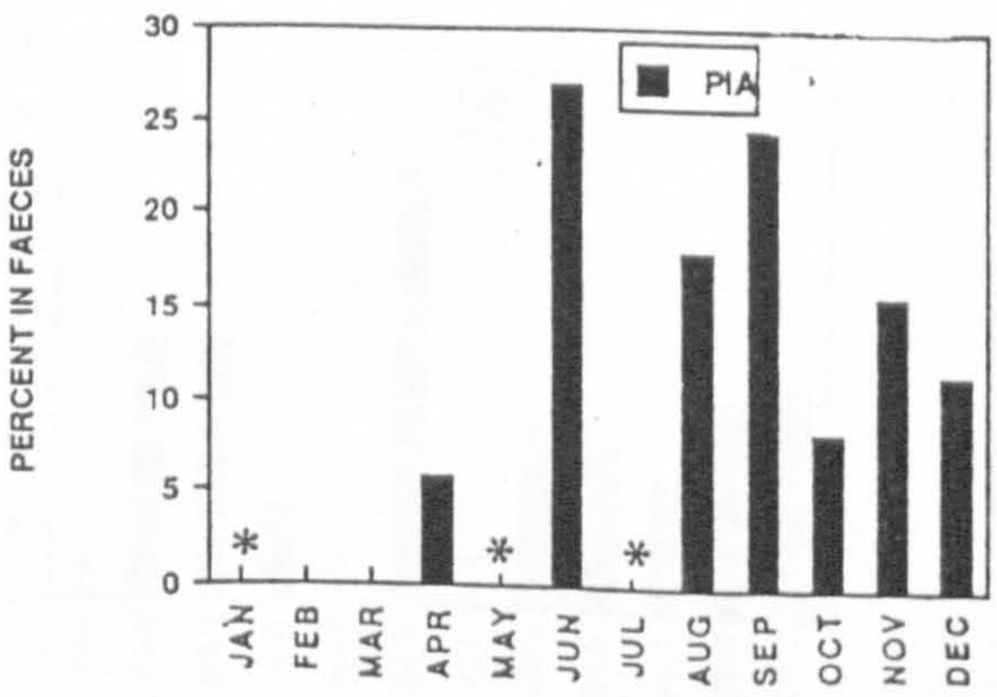
Percent frequency of broadleaved trees in the faeces.

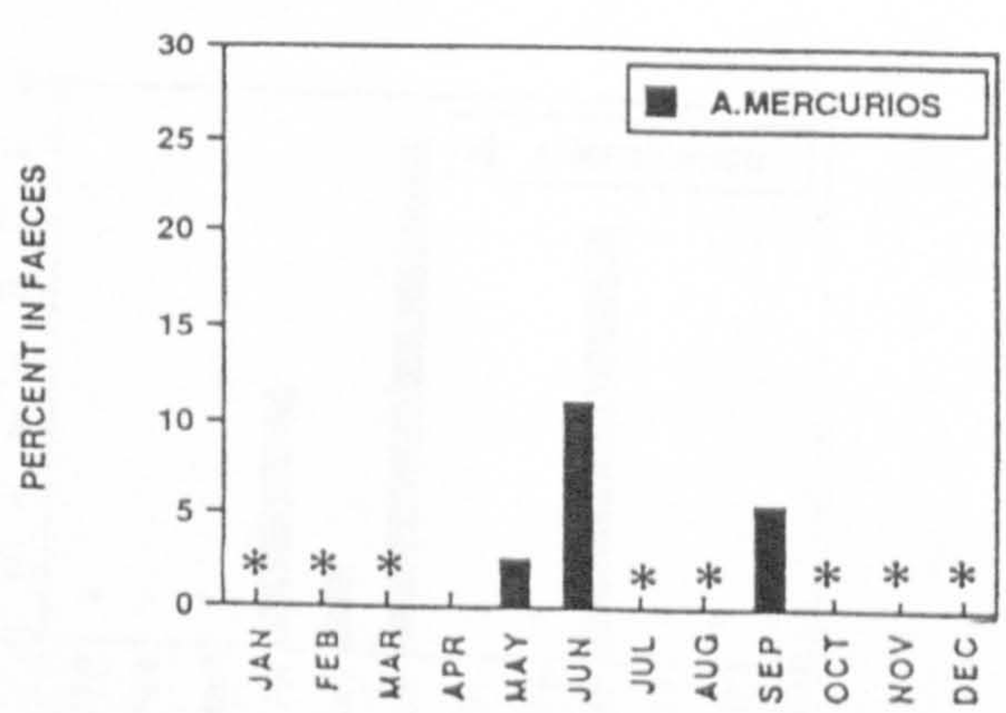
For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS AND LIMNITIS.

No data=*









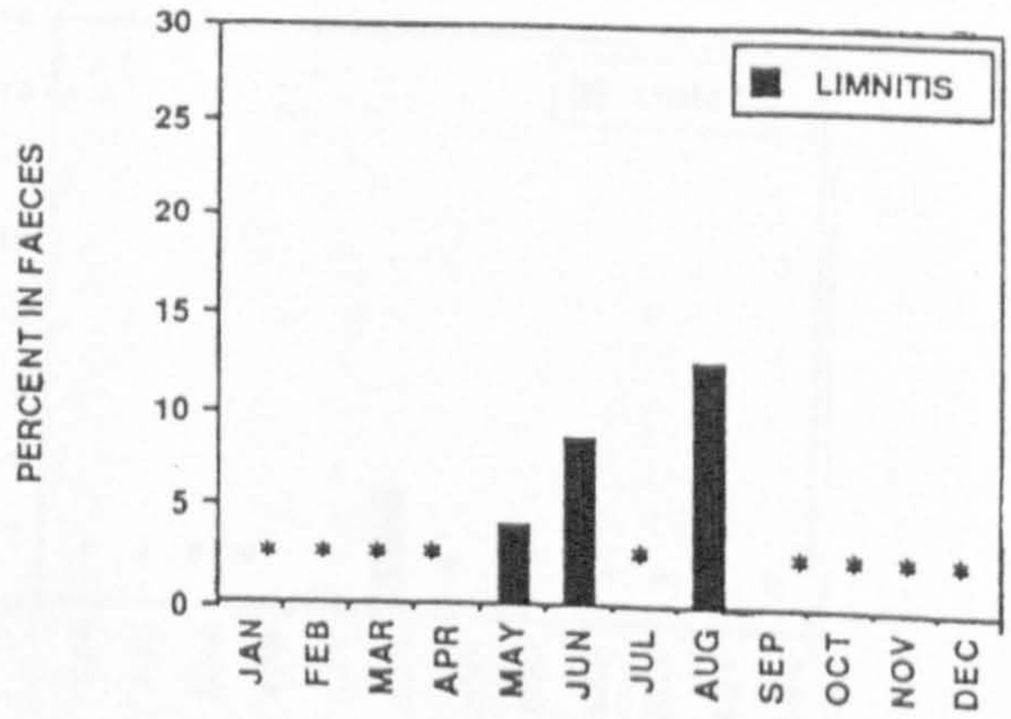
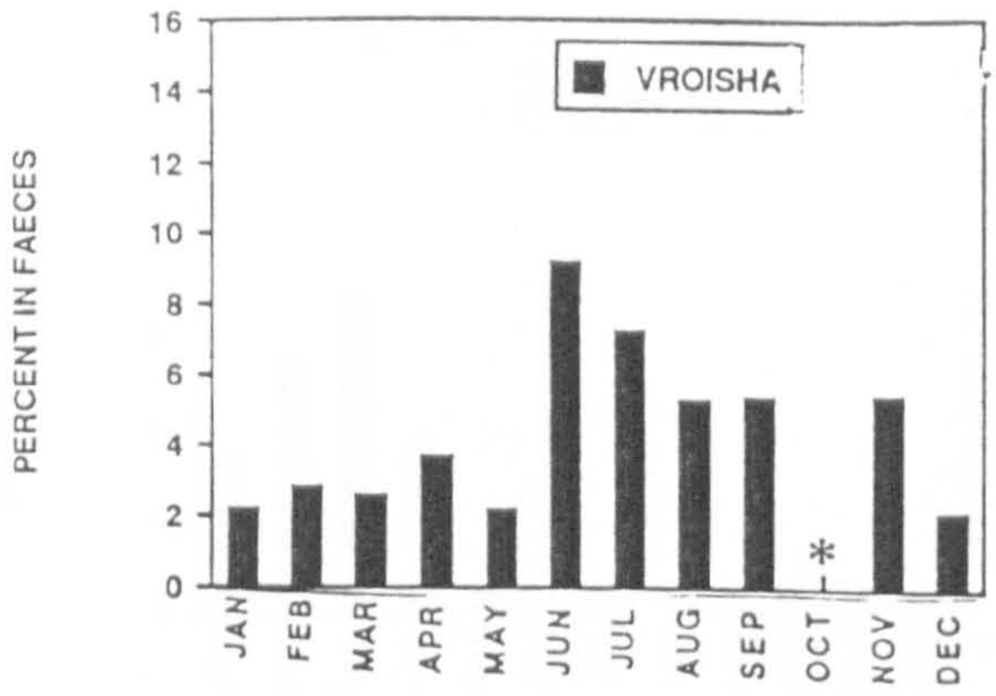
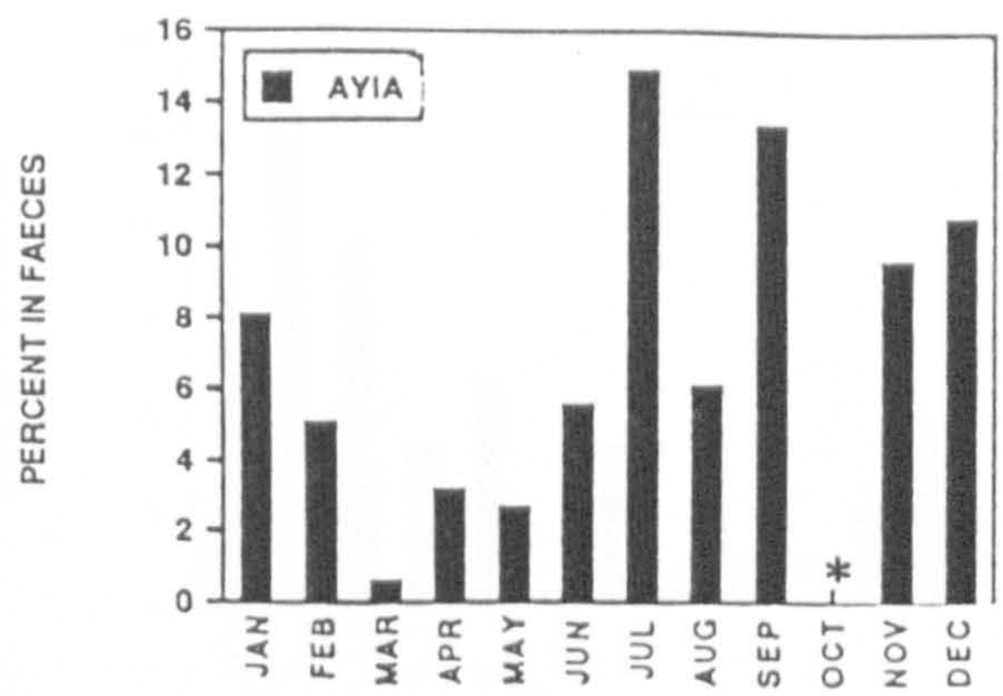


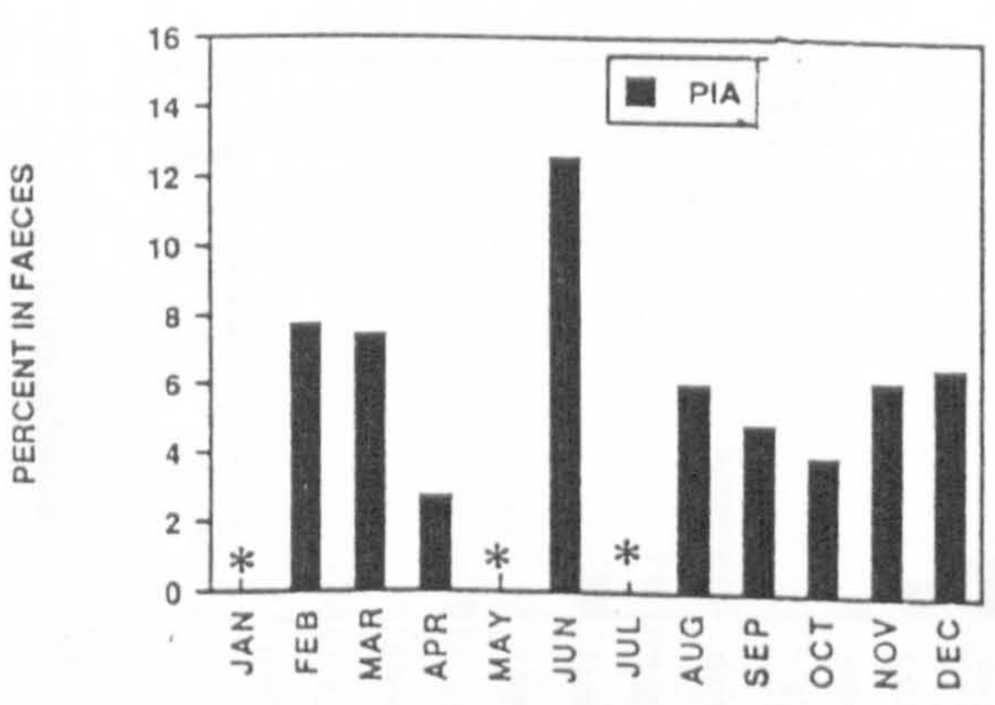
Fig 4.5

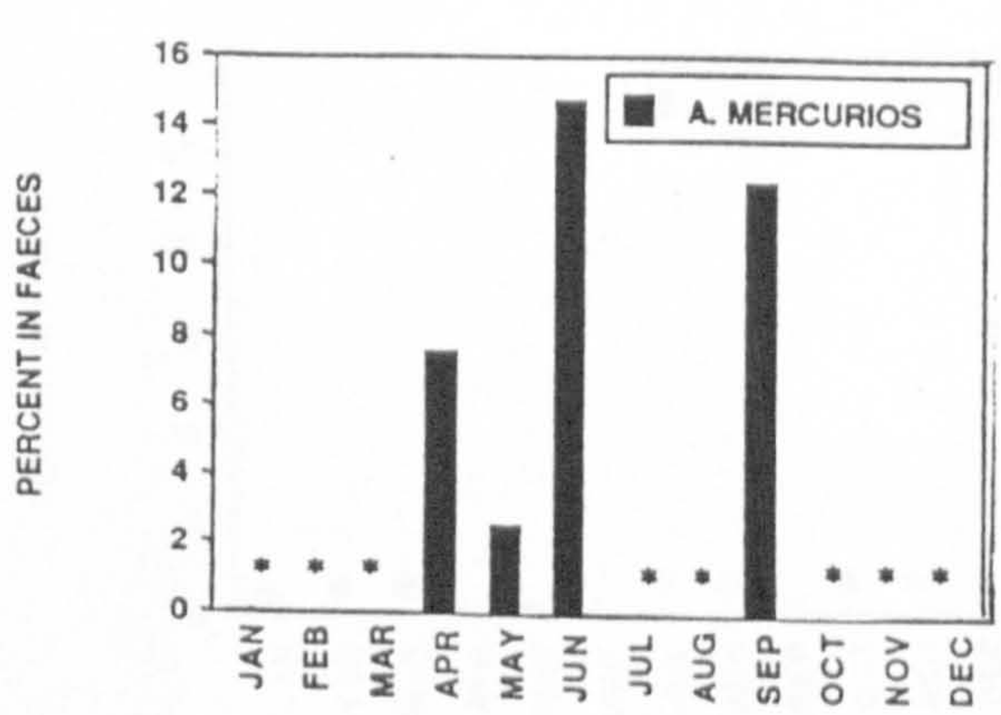
Percent frequency of *Trifolium clypeatum* and *Pistacia terebinthus* in the faeces.

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS AND LIMNITIS.
No data=*









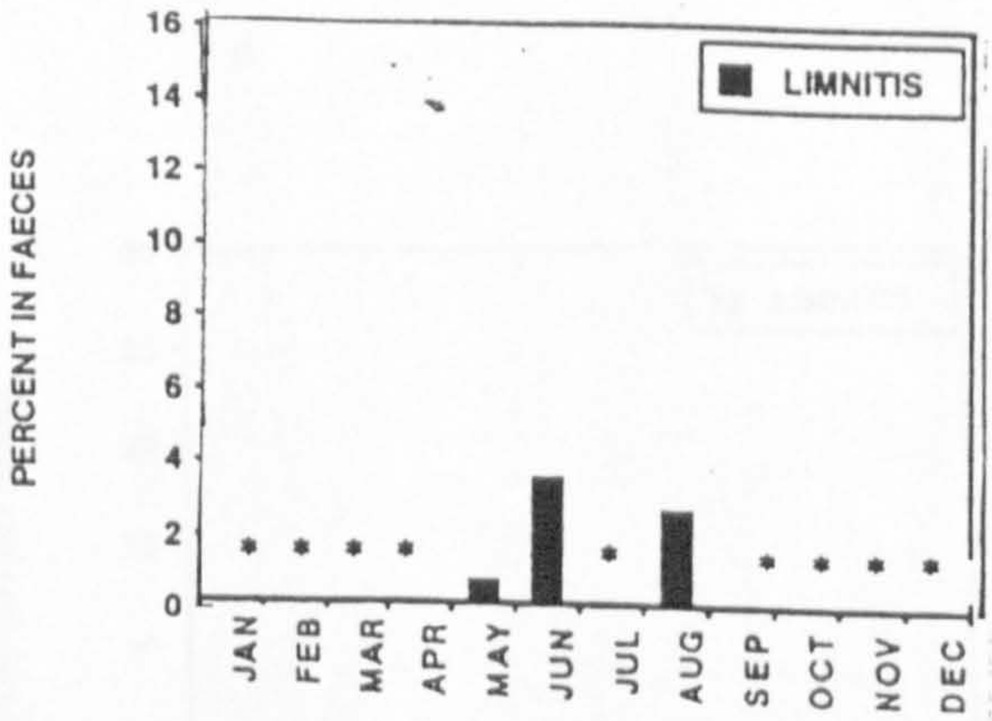


Fig 4.6

Percent frequency of *Cistus* spp. in the faeces.

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS AND LIMNITIS.
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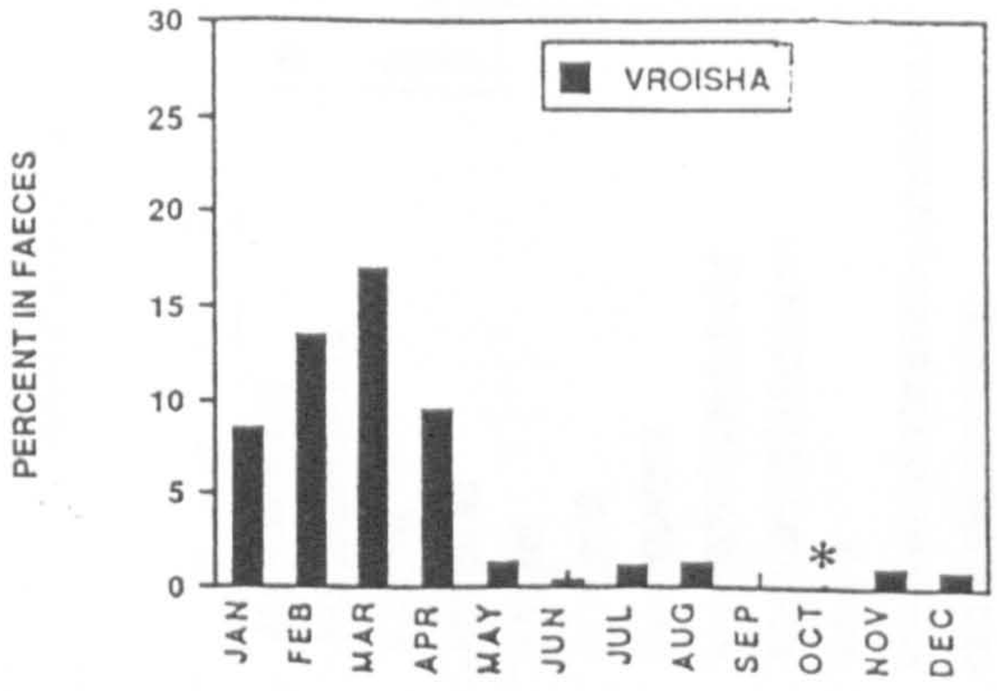
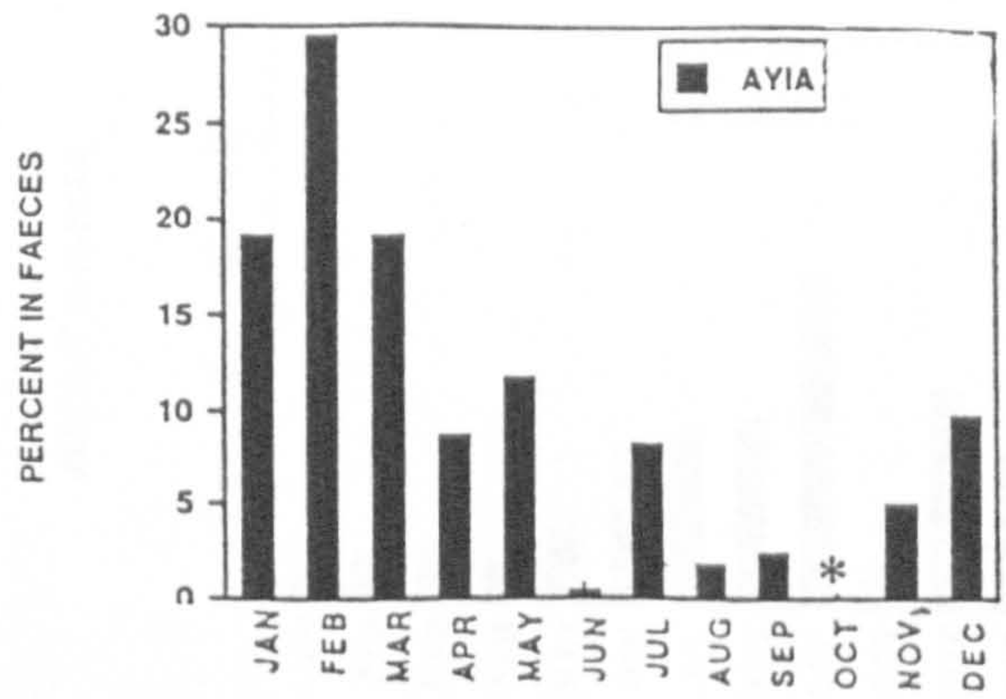
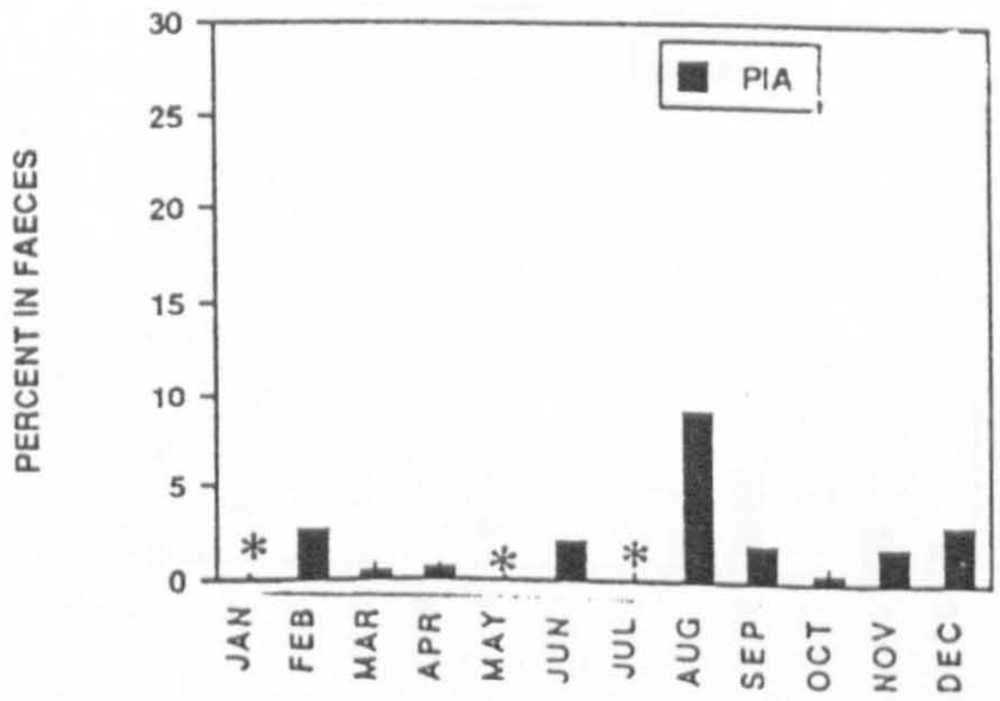
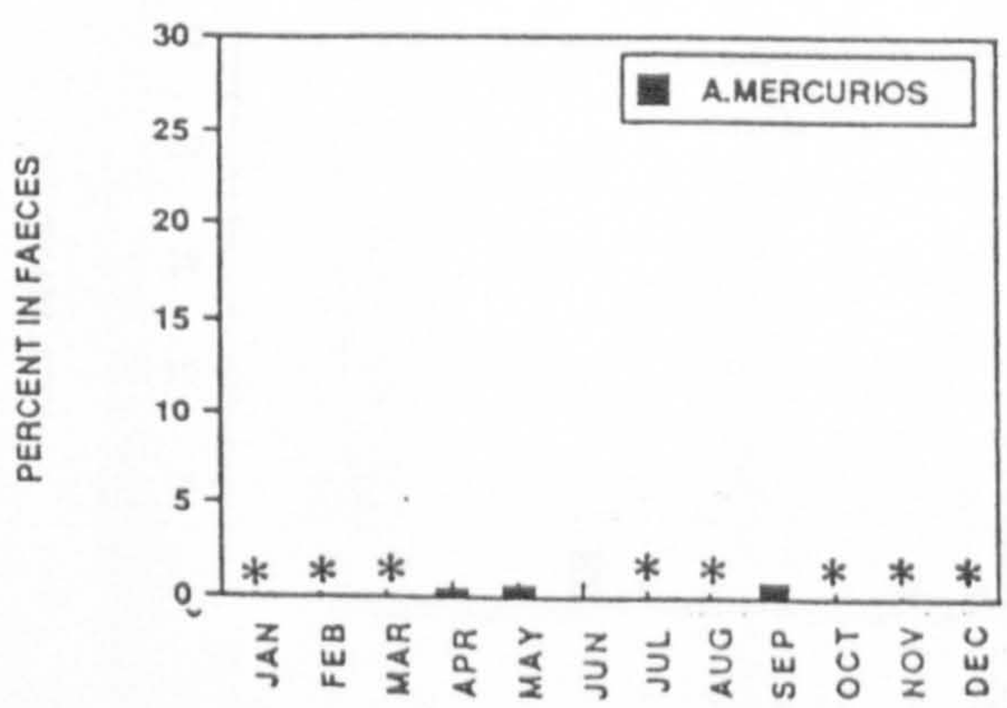








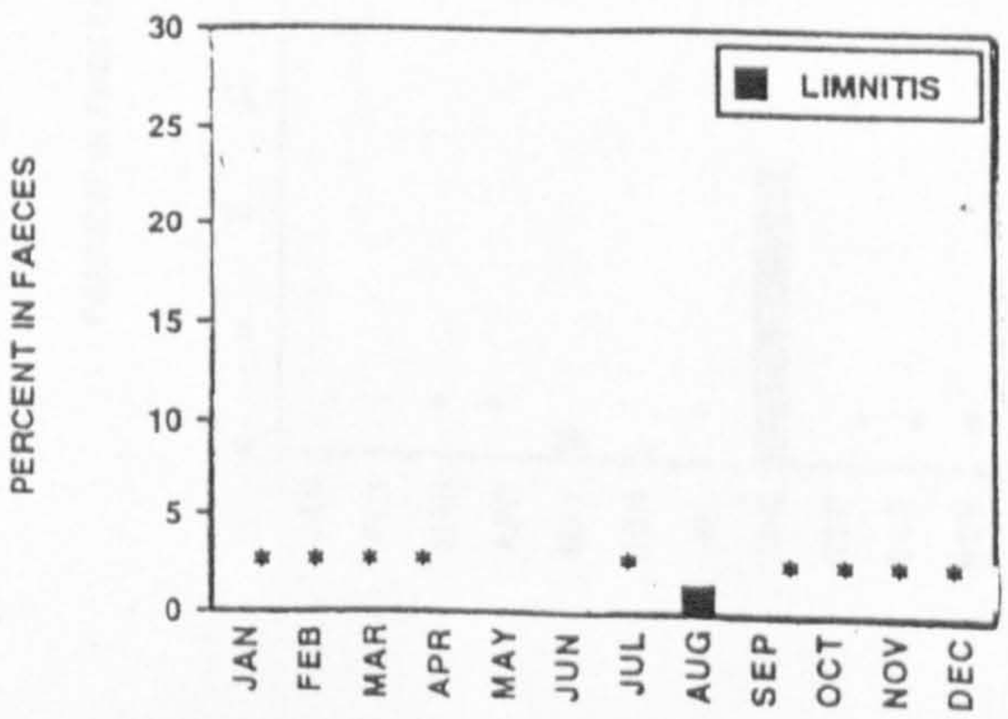
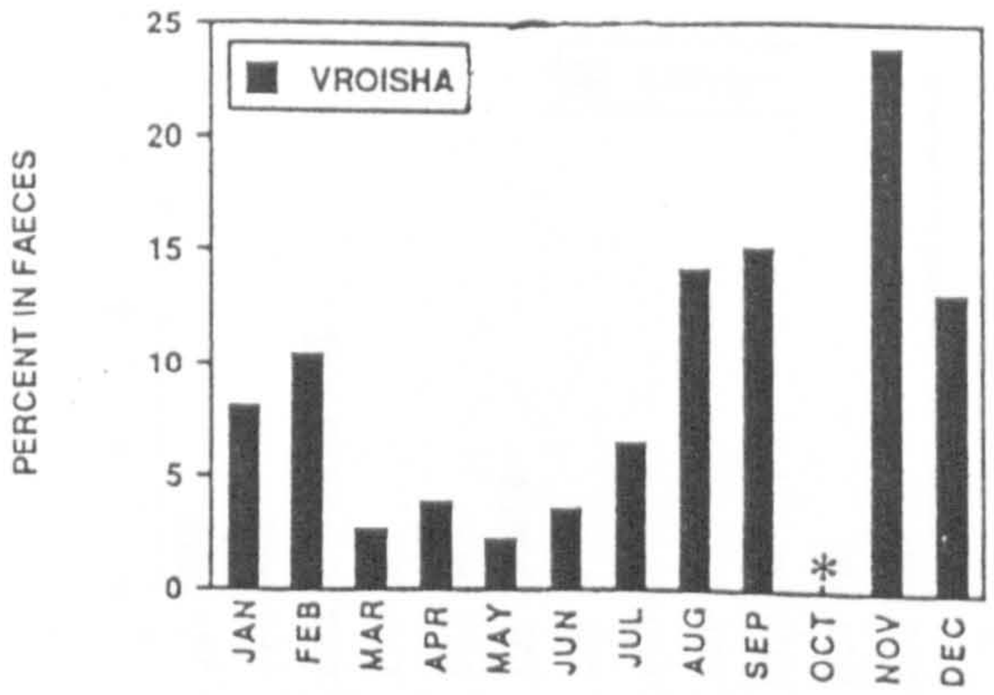


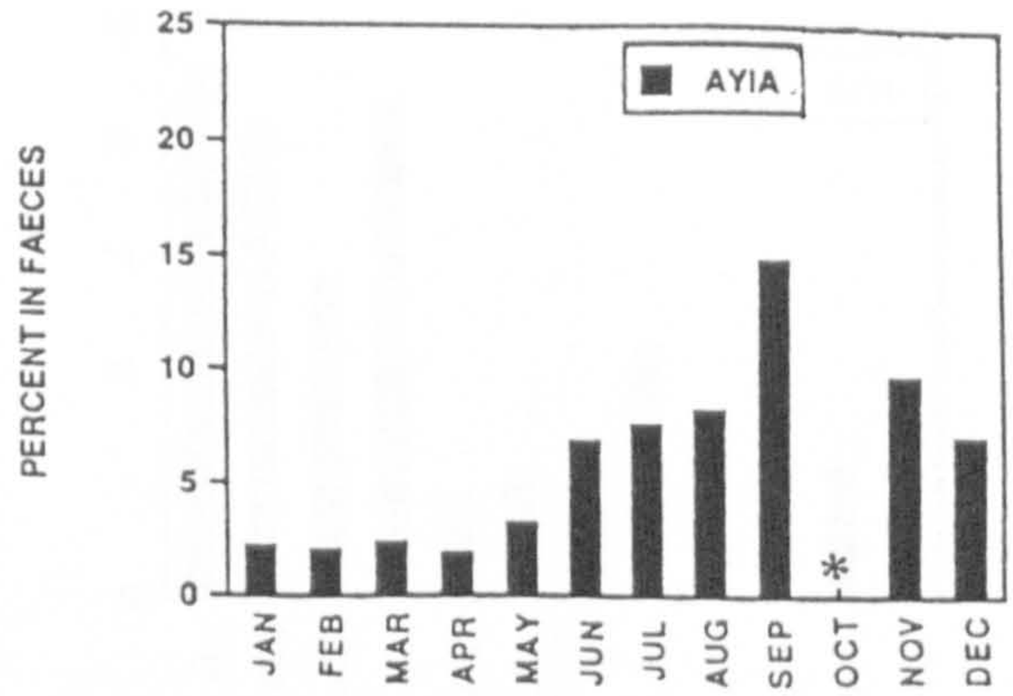
Fig 4.7

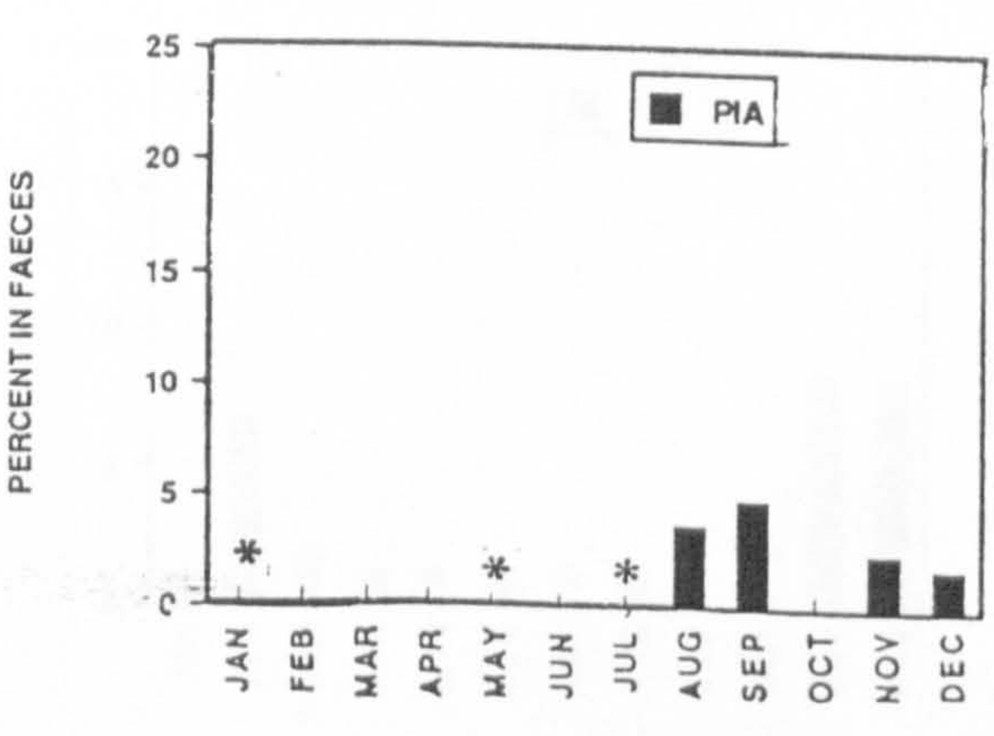
Percent frequency of *Asphodelus aestivus* in the faeces.

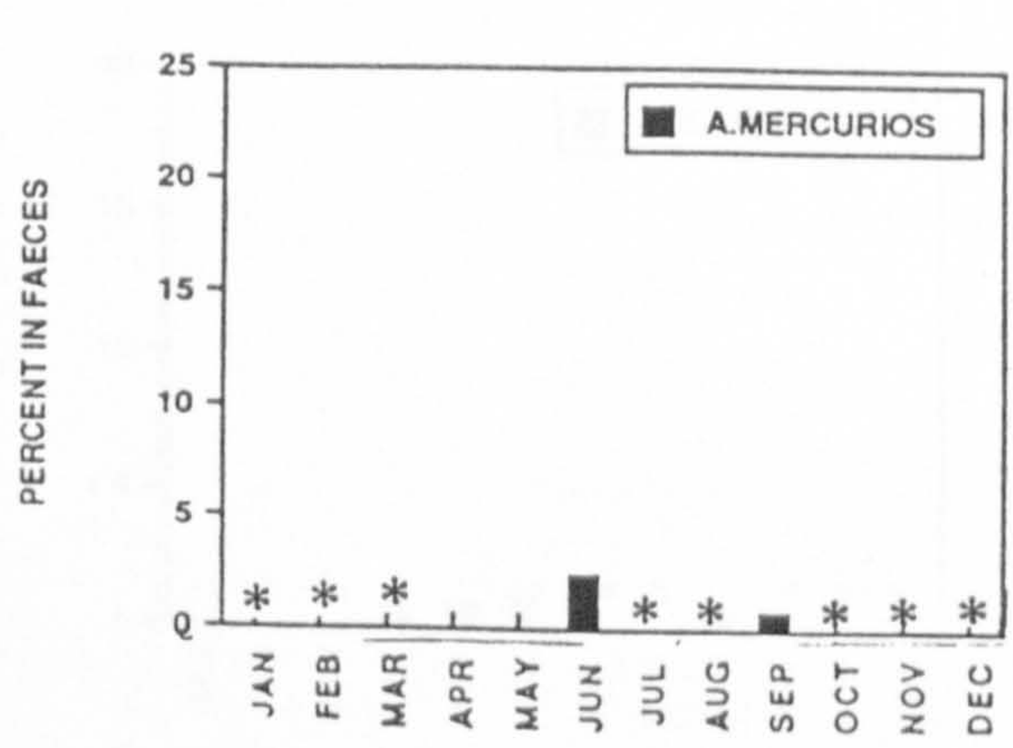
For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS AND LIMNITIS.

No data=*









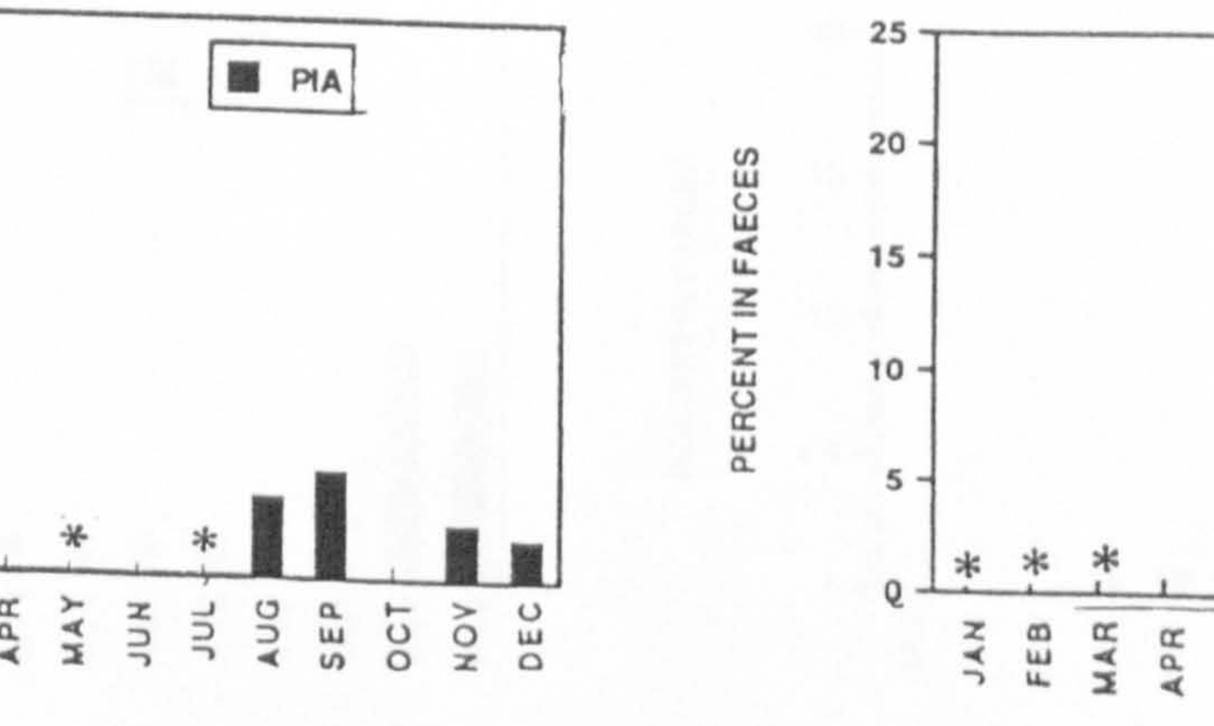
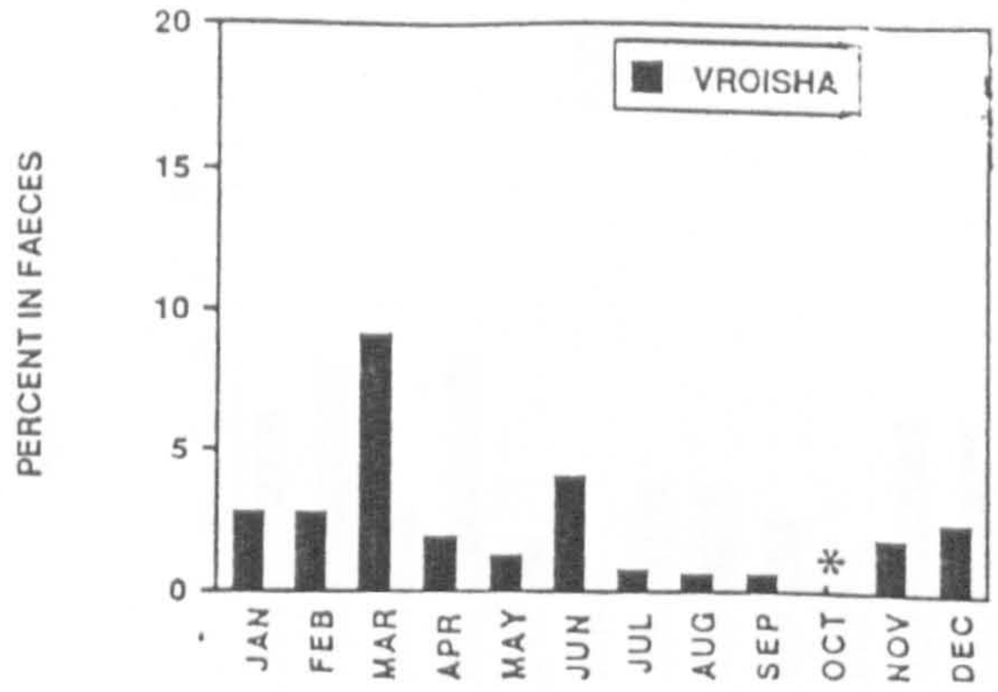
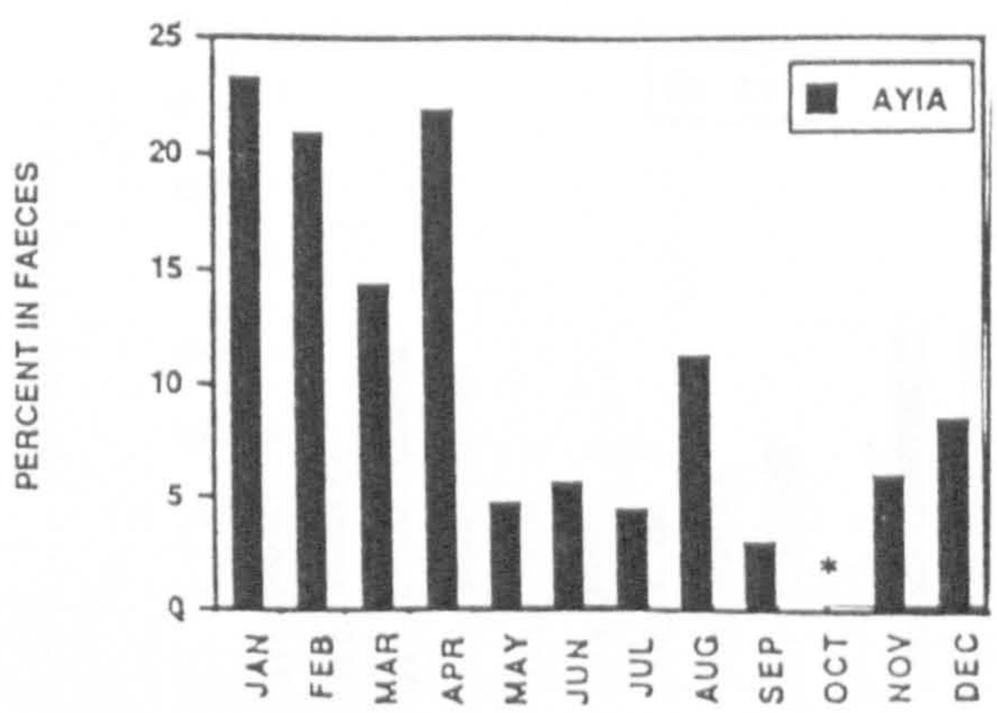


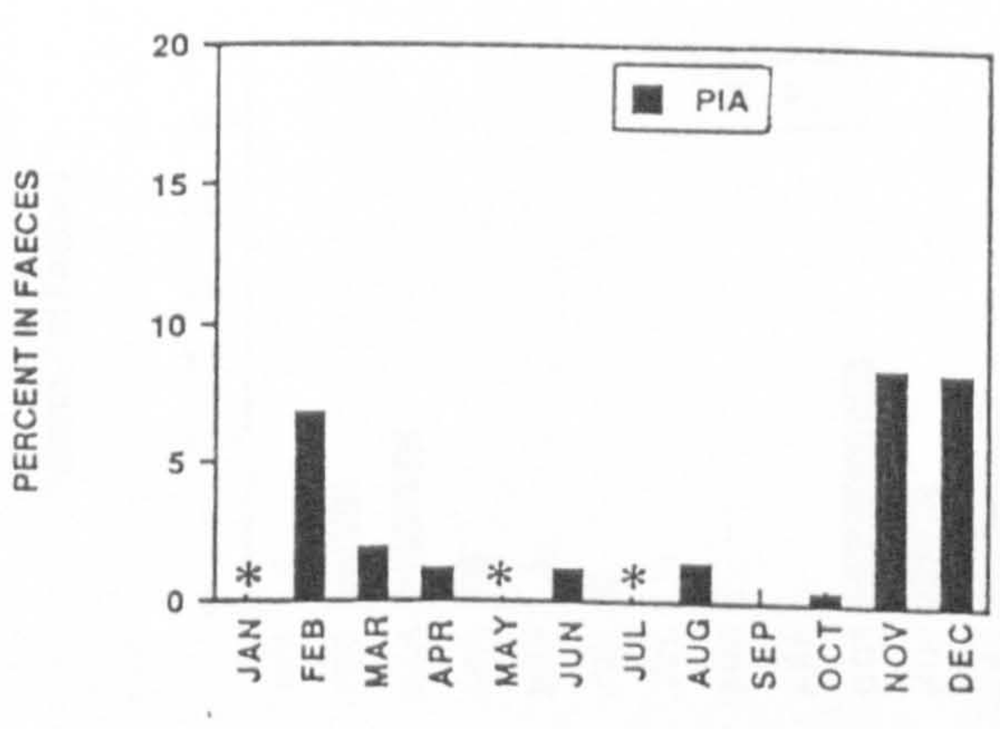
Fig 4.8

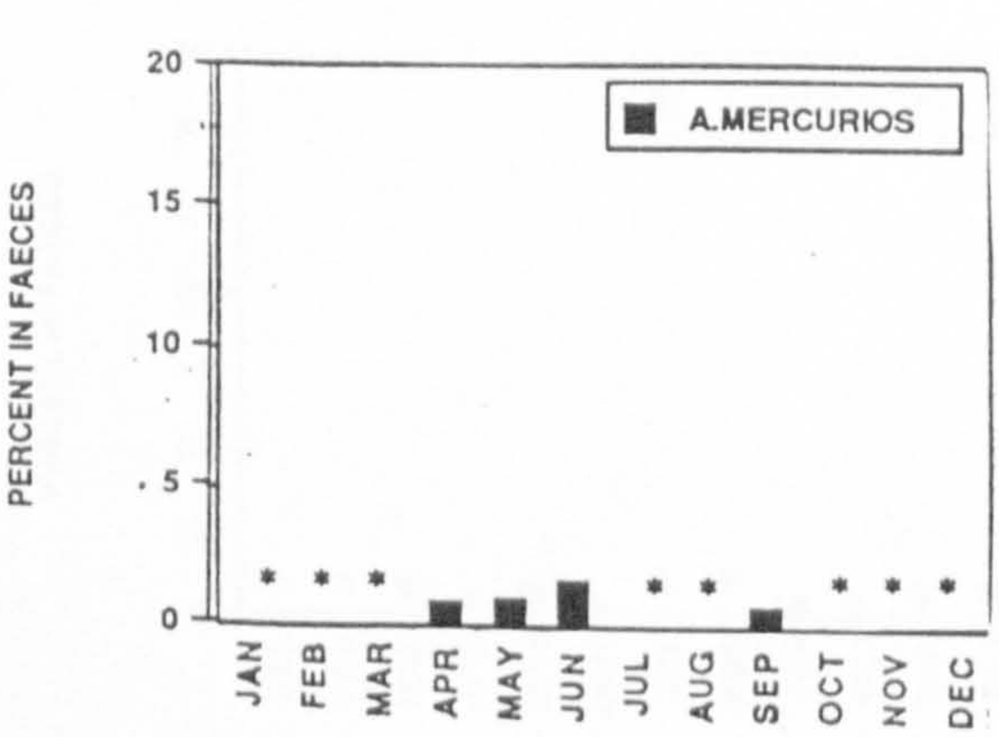
Percent frequency of *Teucrium kotschyanum* in the faeces.

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS AND LIMNITIS.
No data=*









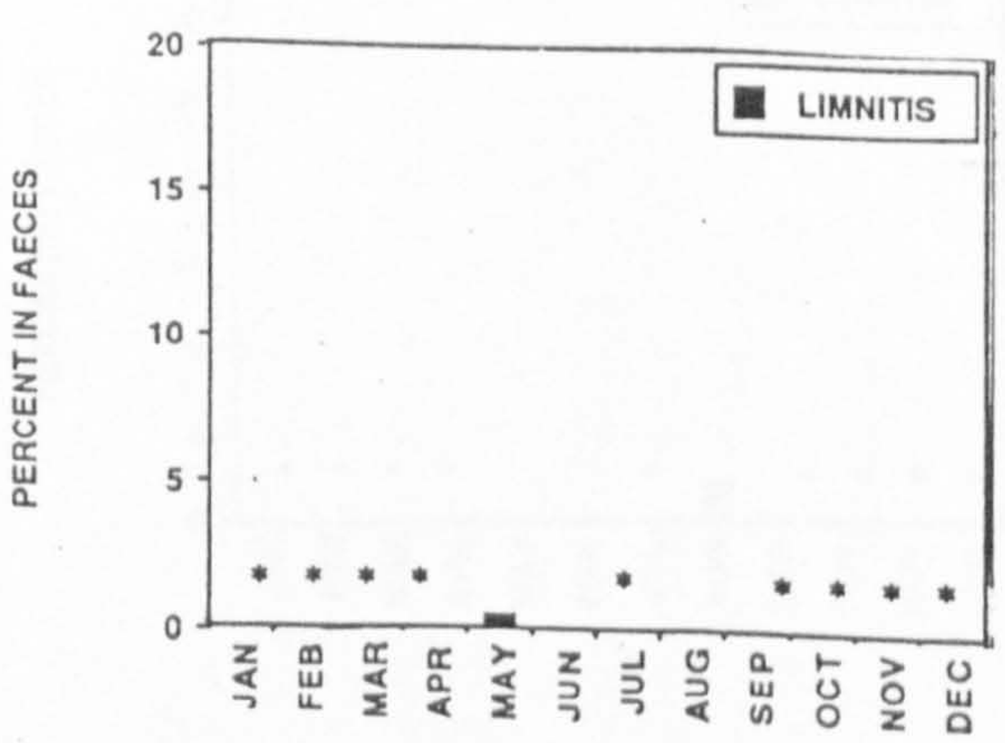
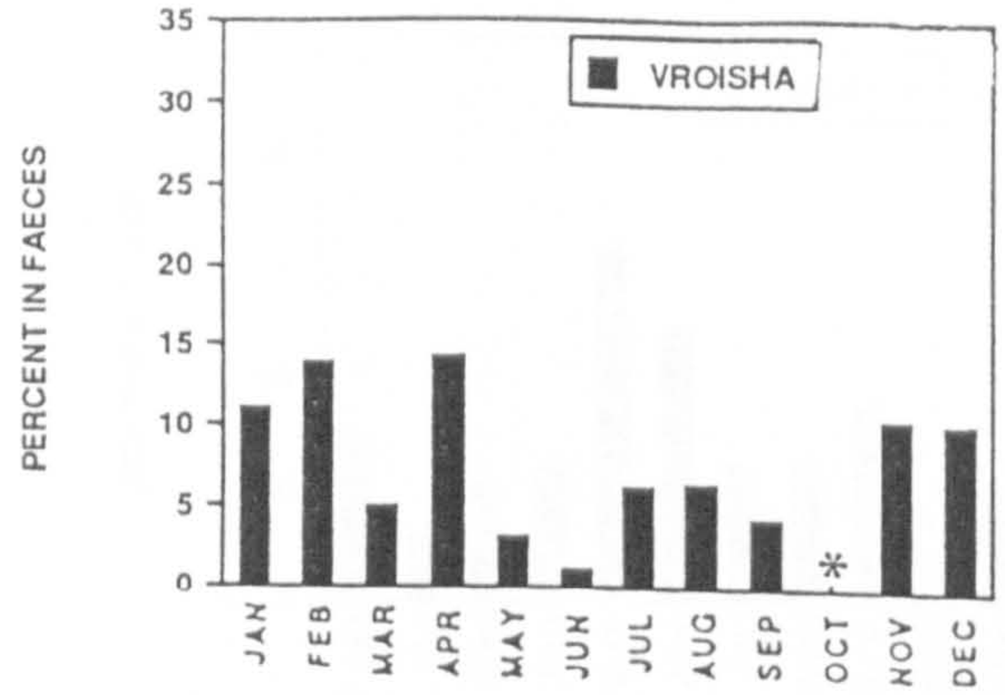
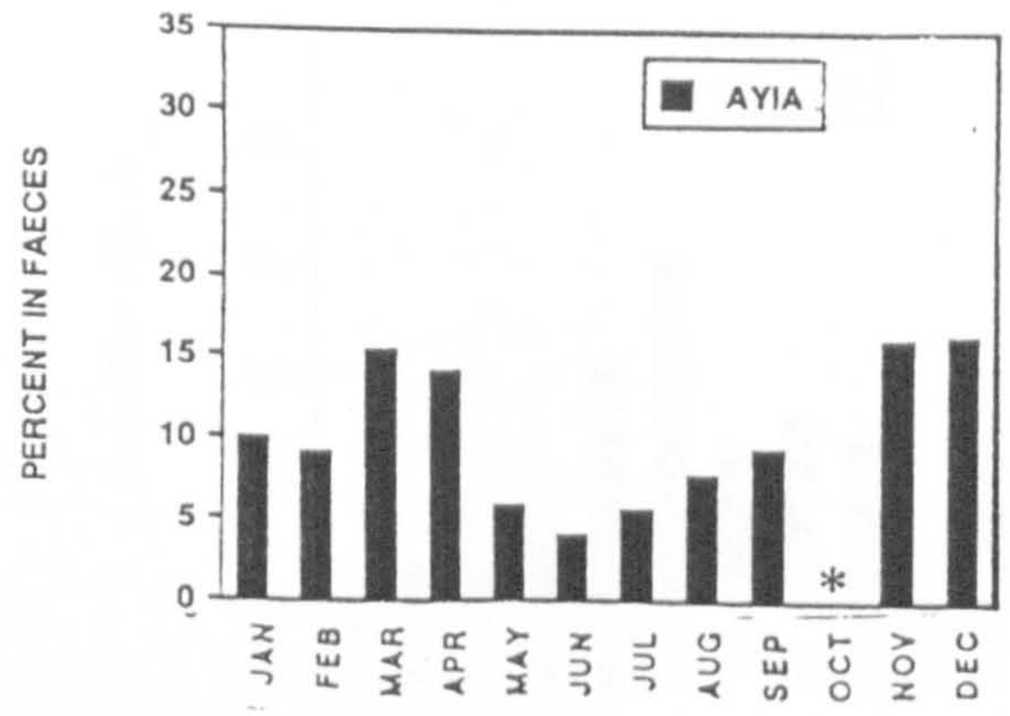


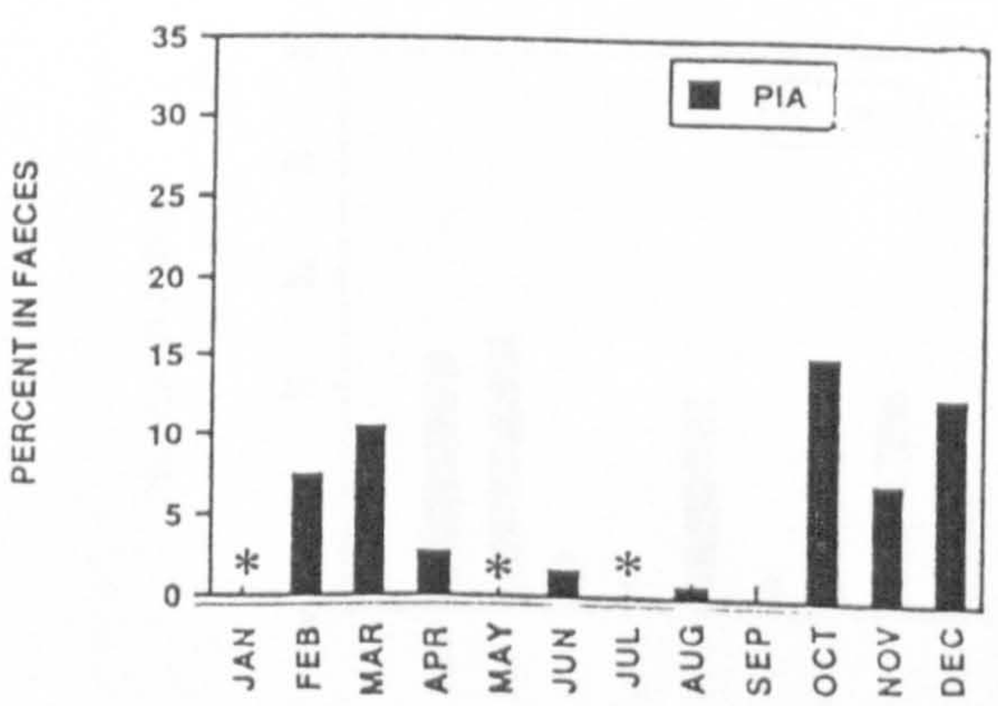
Fig 4.9

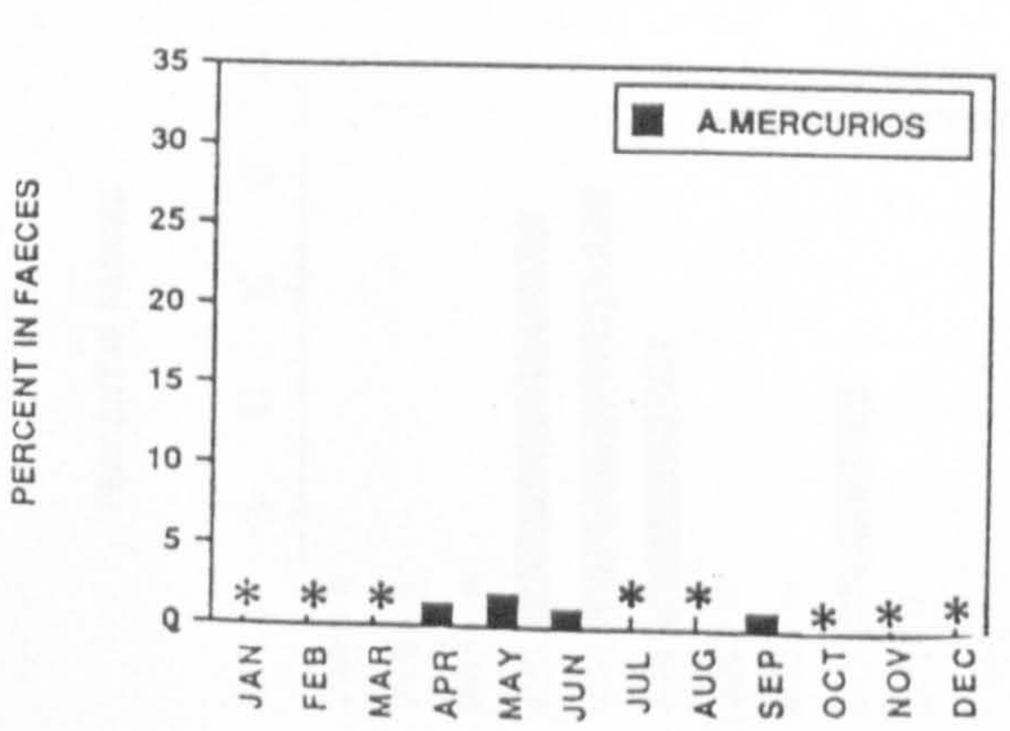
Percent frequency of *Lithodora hispidula* in the faeces.

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS AND LIMNITIS.
No data=*









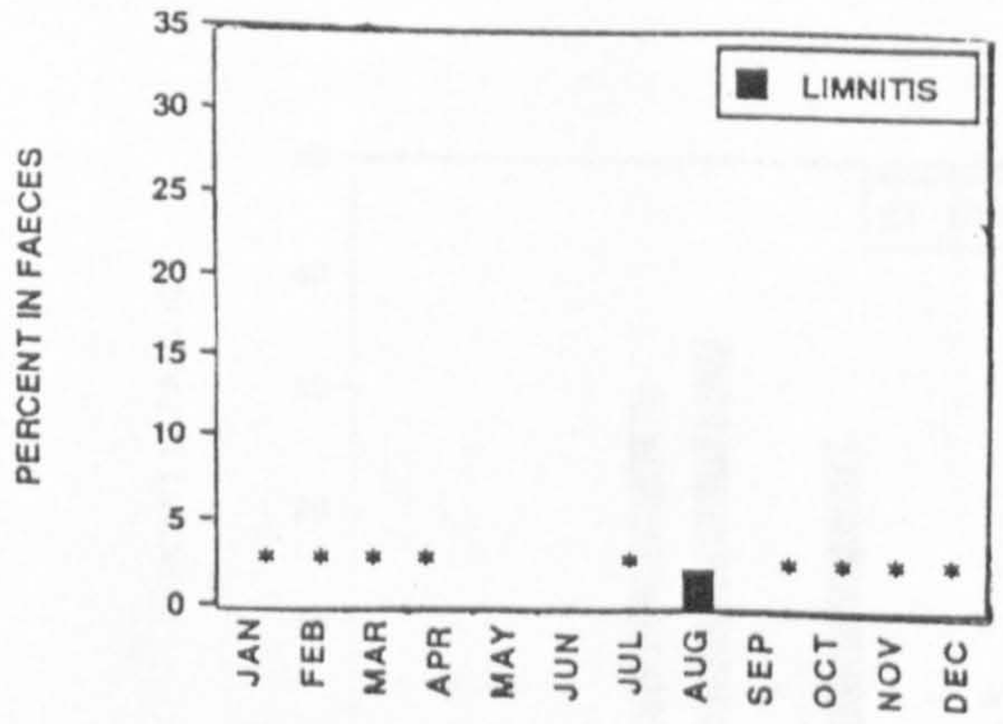


Fig 4.10

Percent frequency of non-graminaceous monocotyledons in the faeces.

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS AND LIMNITIS.

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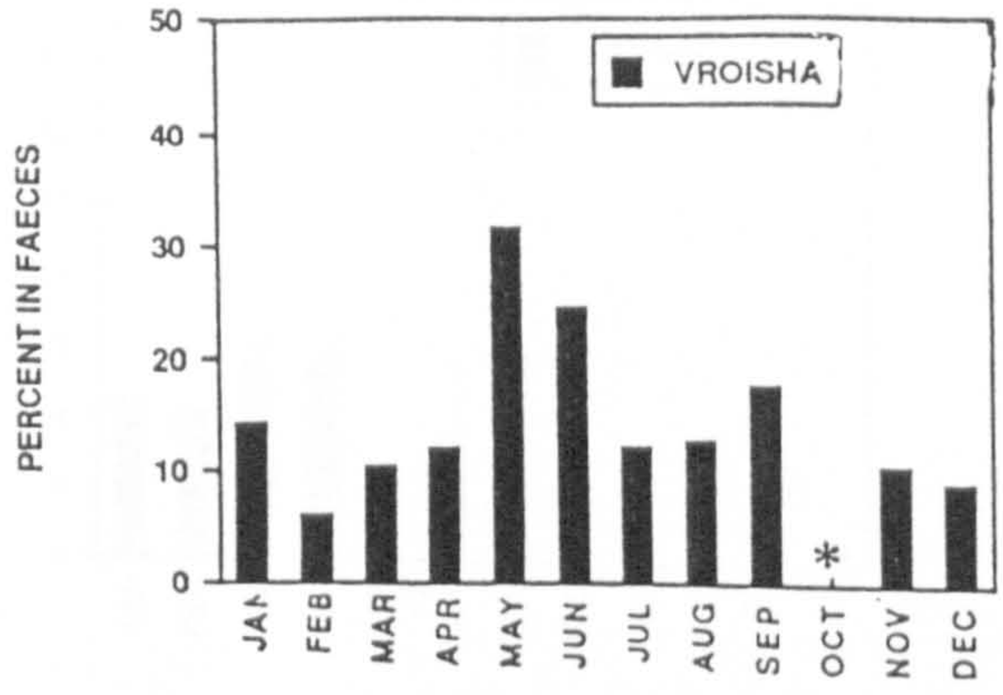

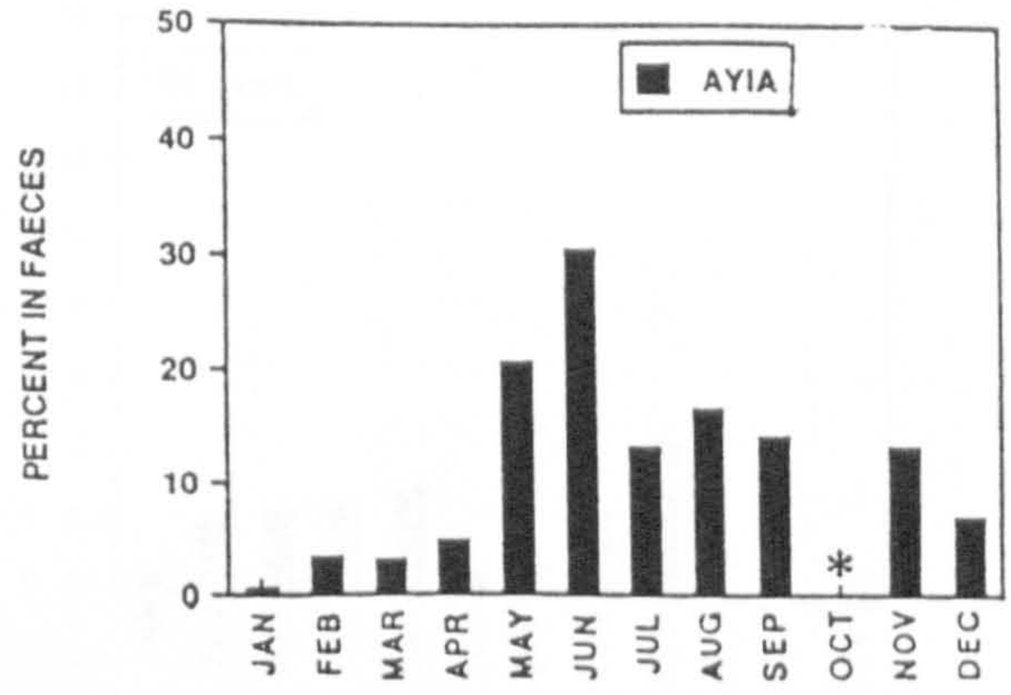

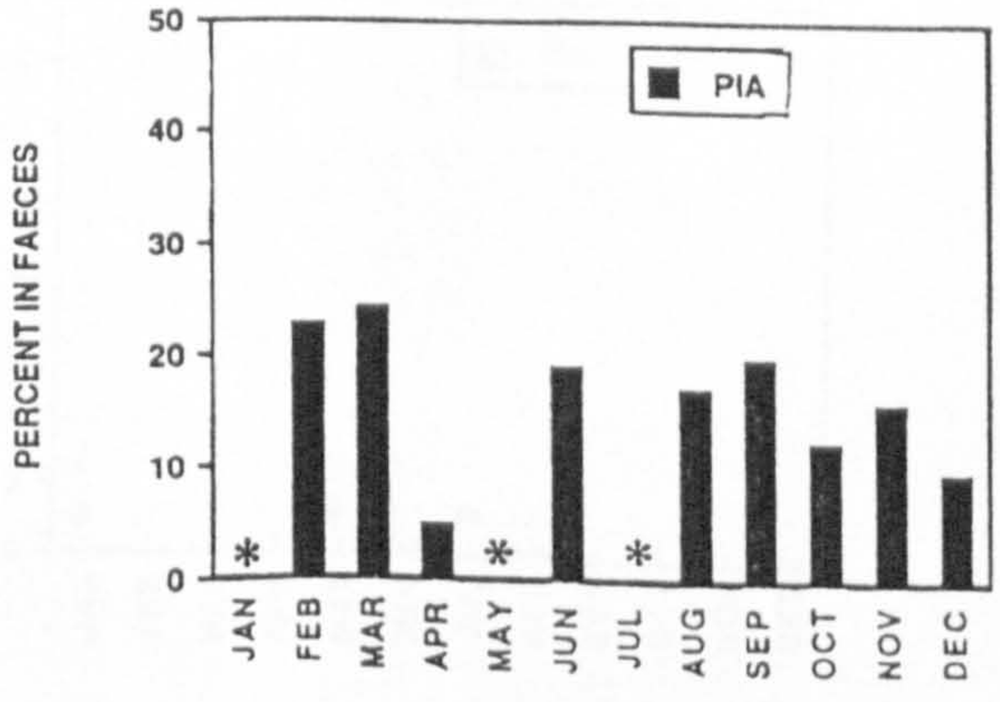

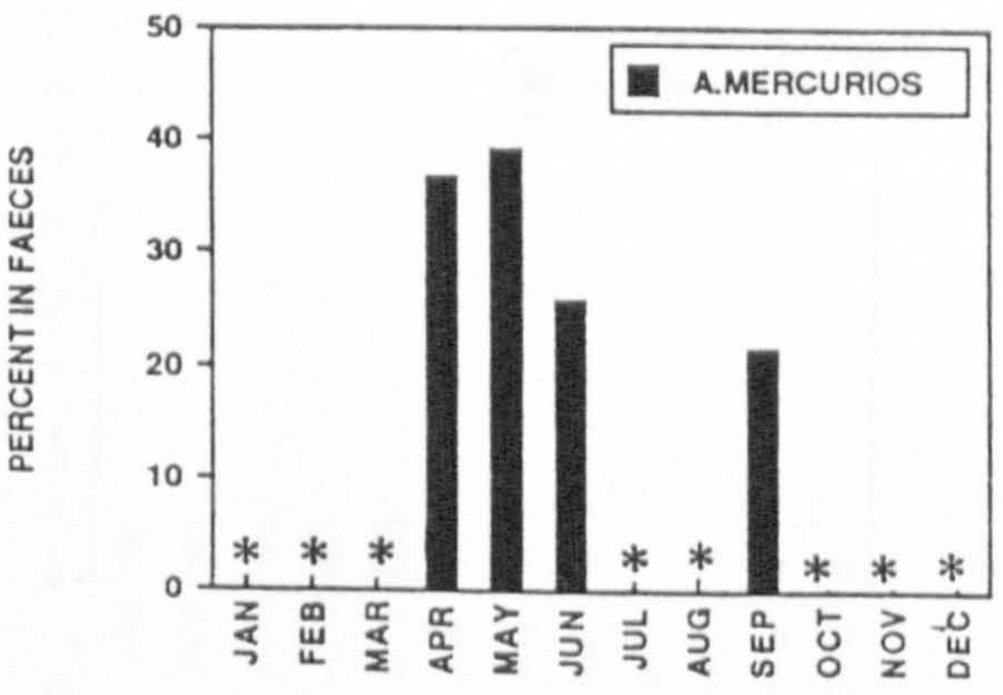

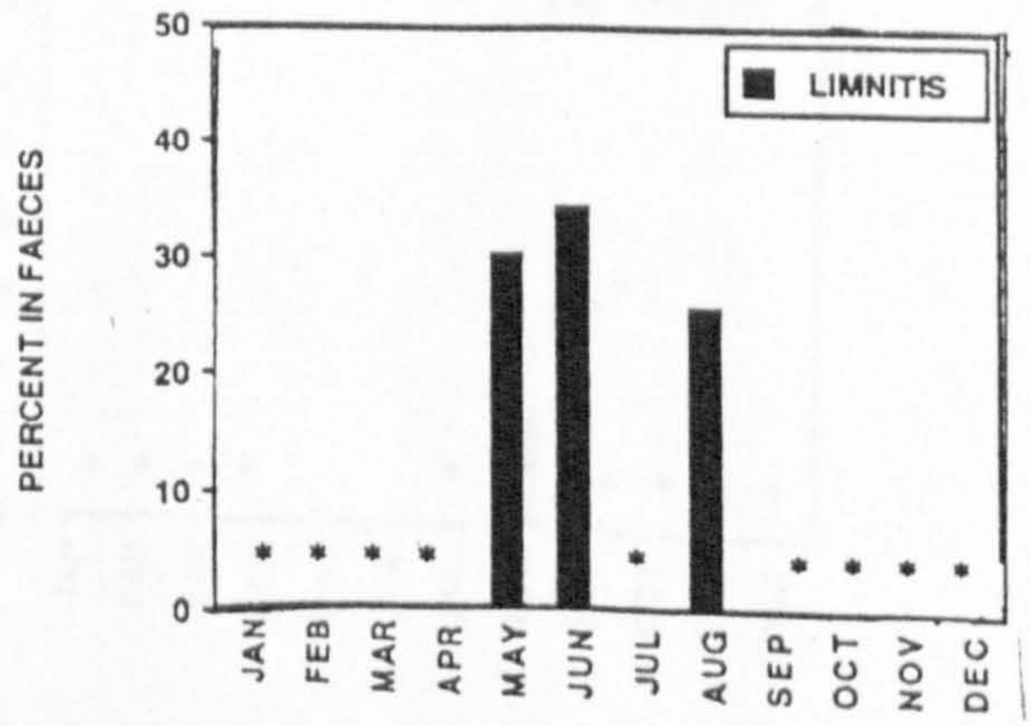

Fig 4.11

Percent frequency of *Pinus brutia* in the faeces.

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS AND LIMNITIS.
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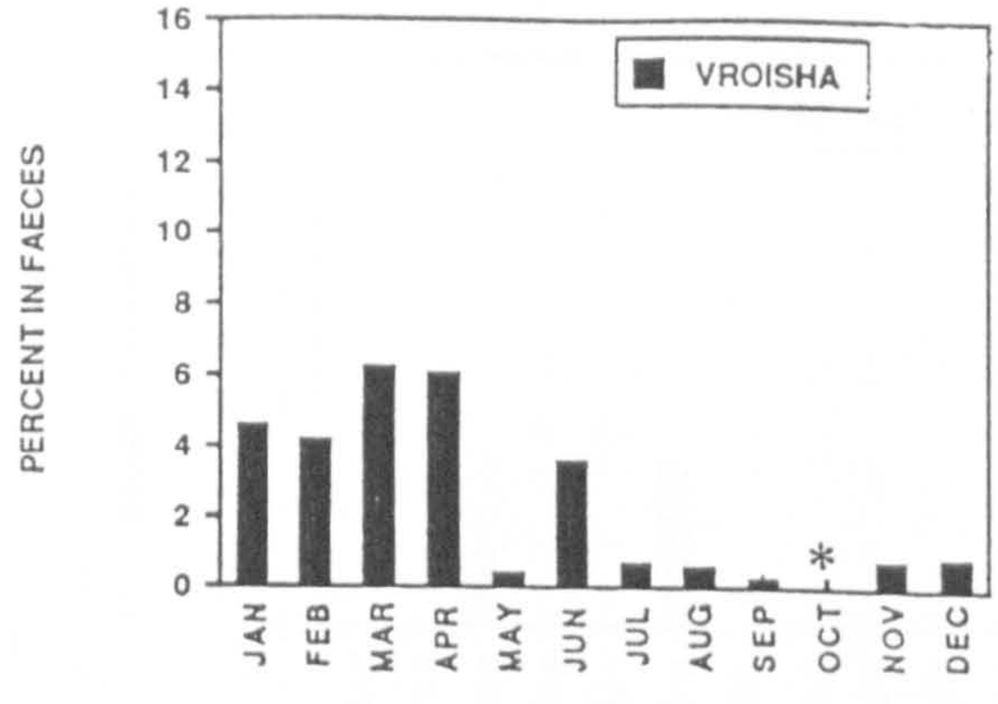

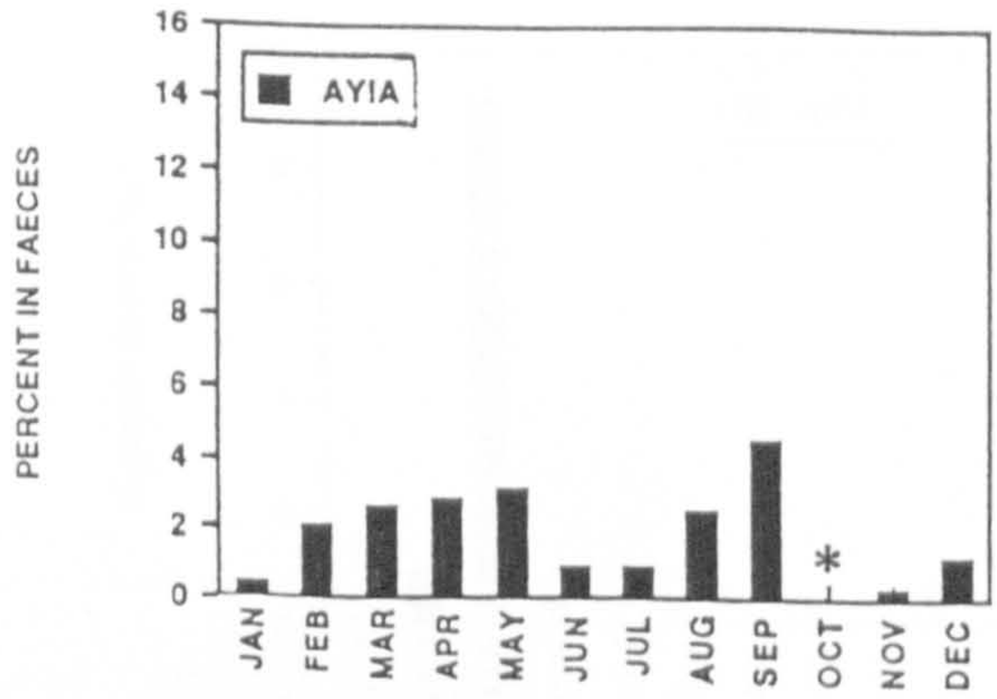

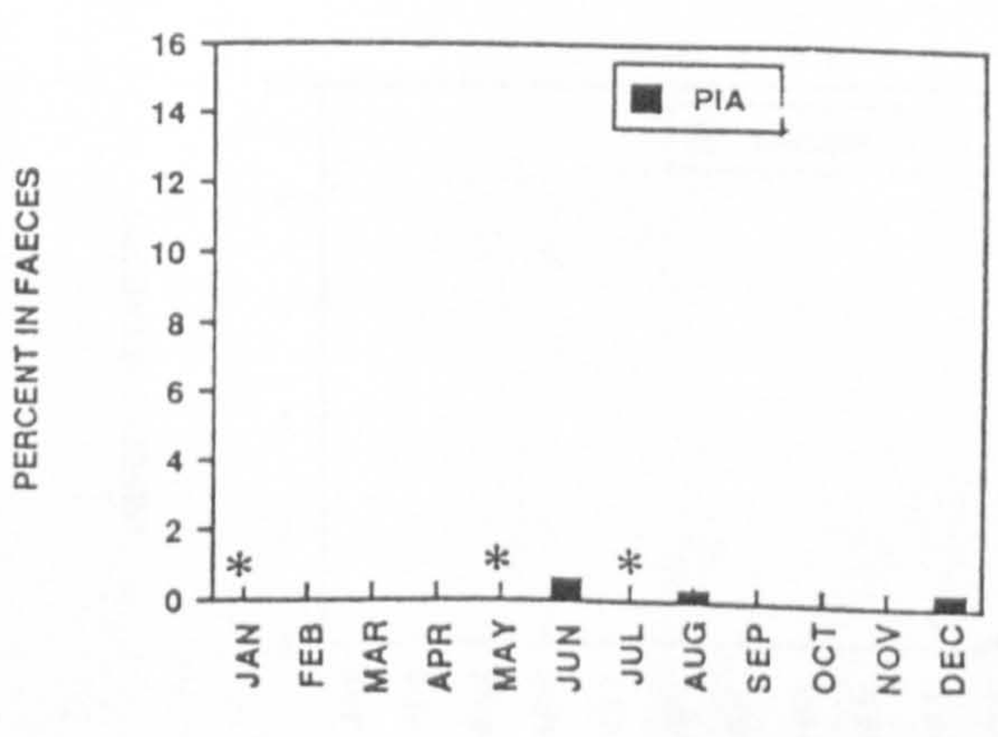

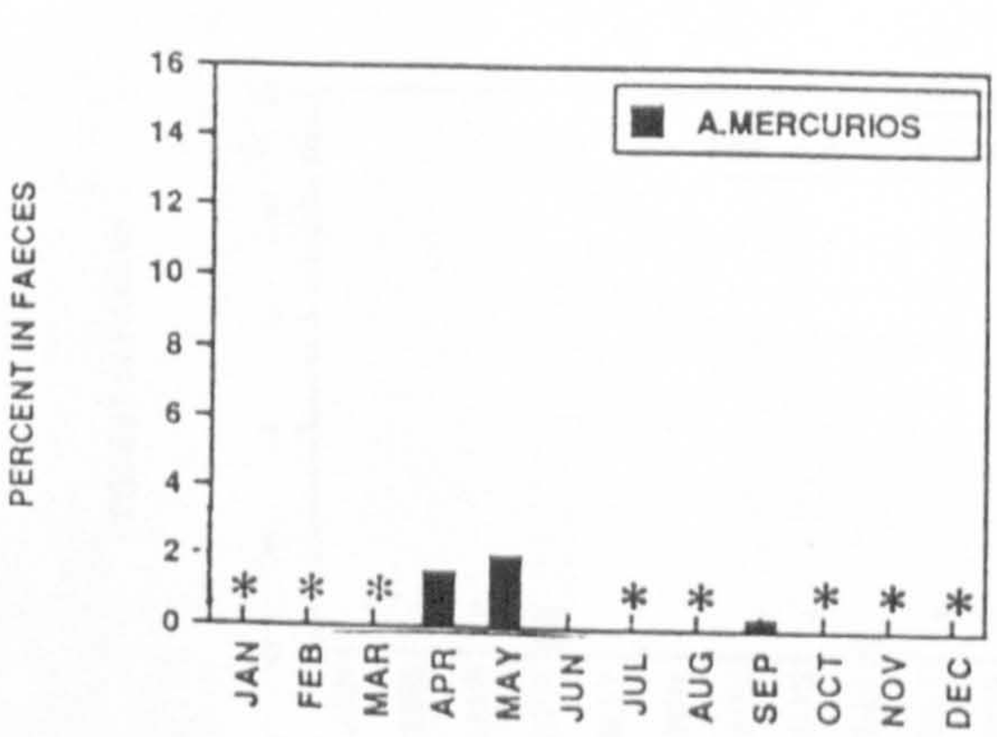

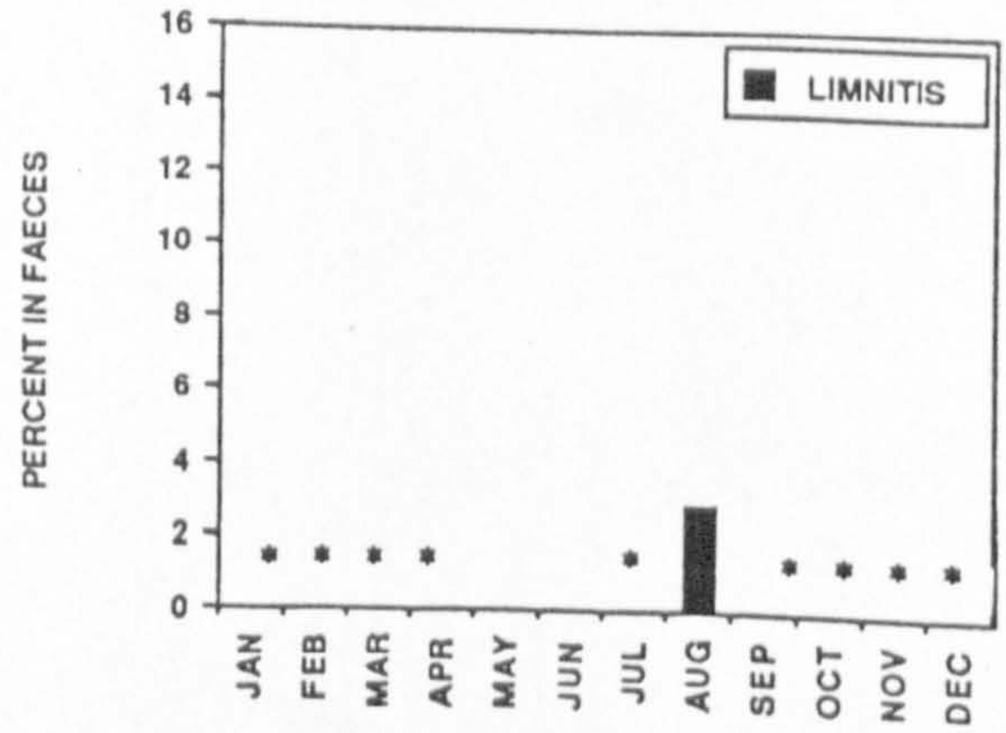

Fig 4.12

Percent frequency of *Rubus sanctus* in the faeces.

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS AND LIMNITIS.
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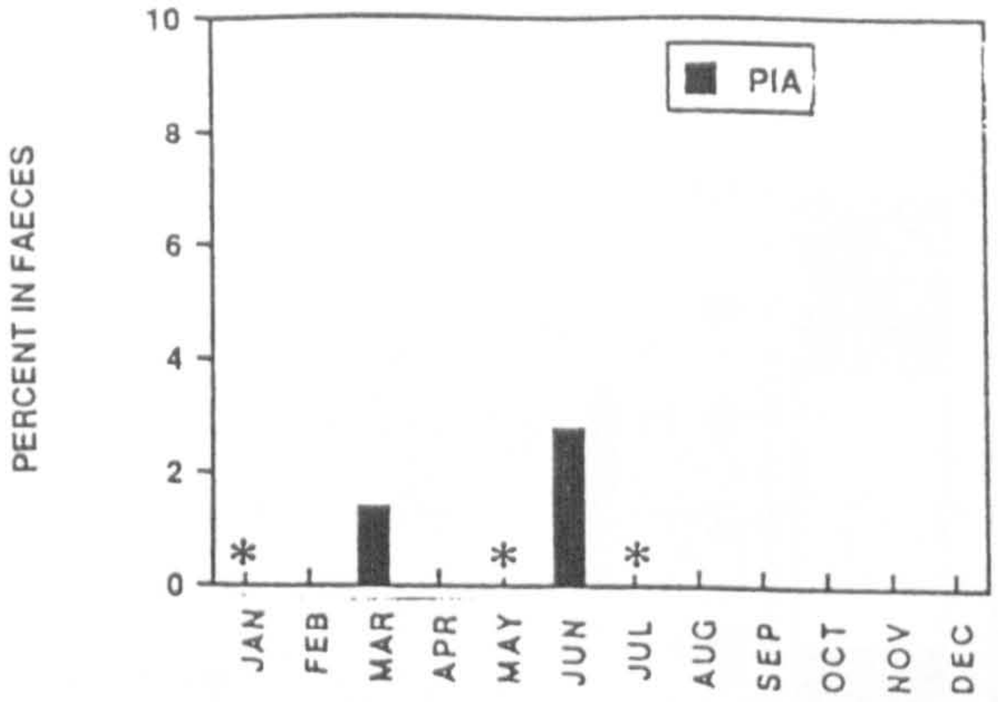
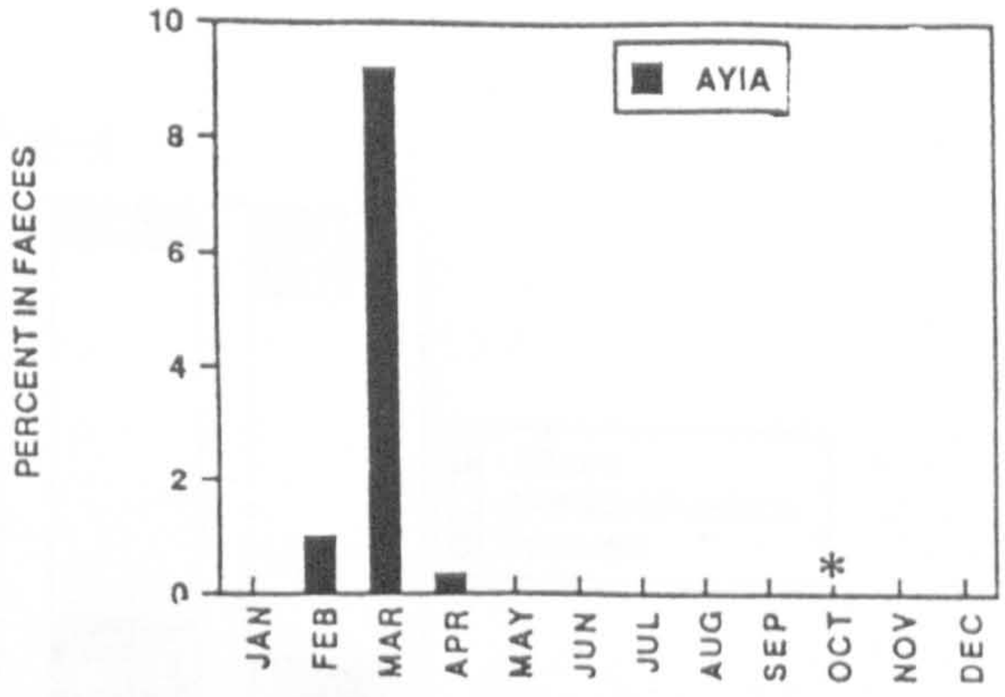
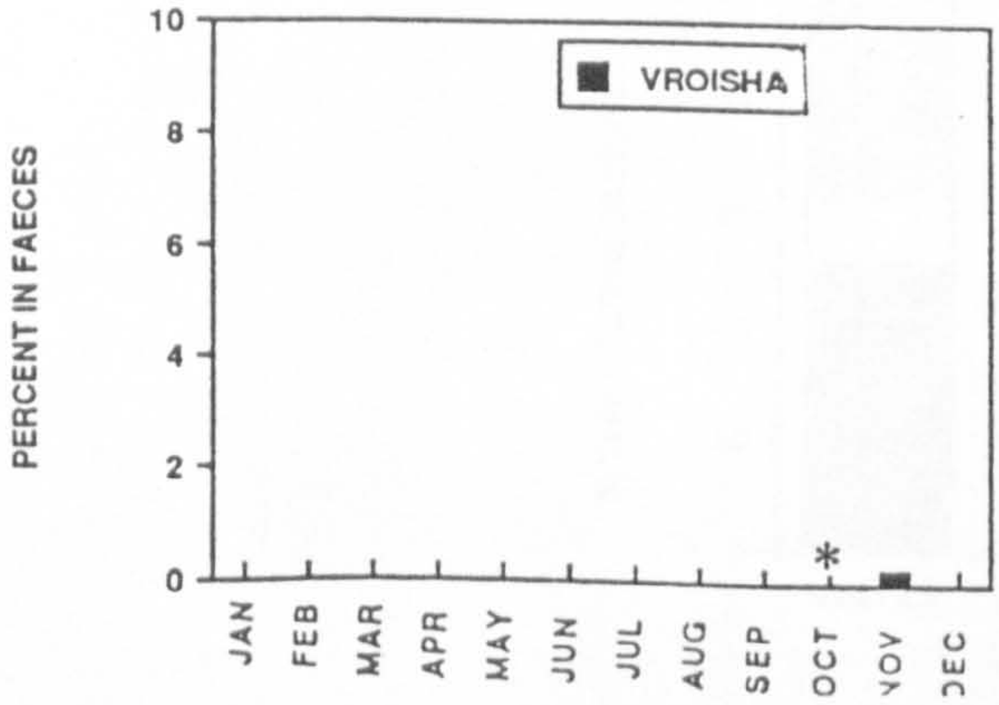






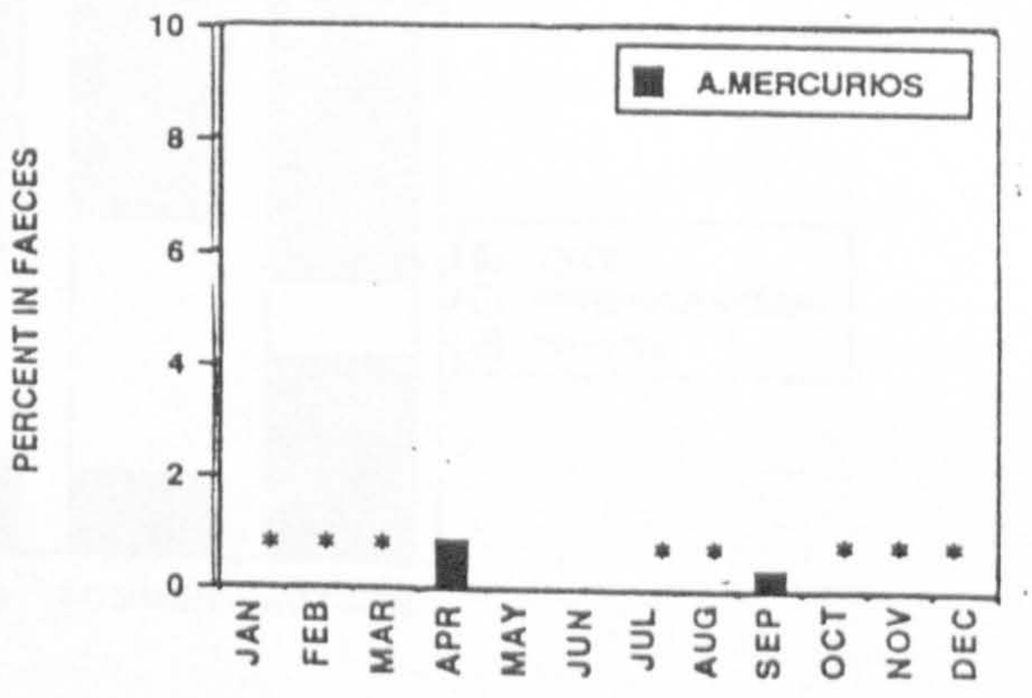
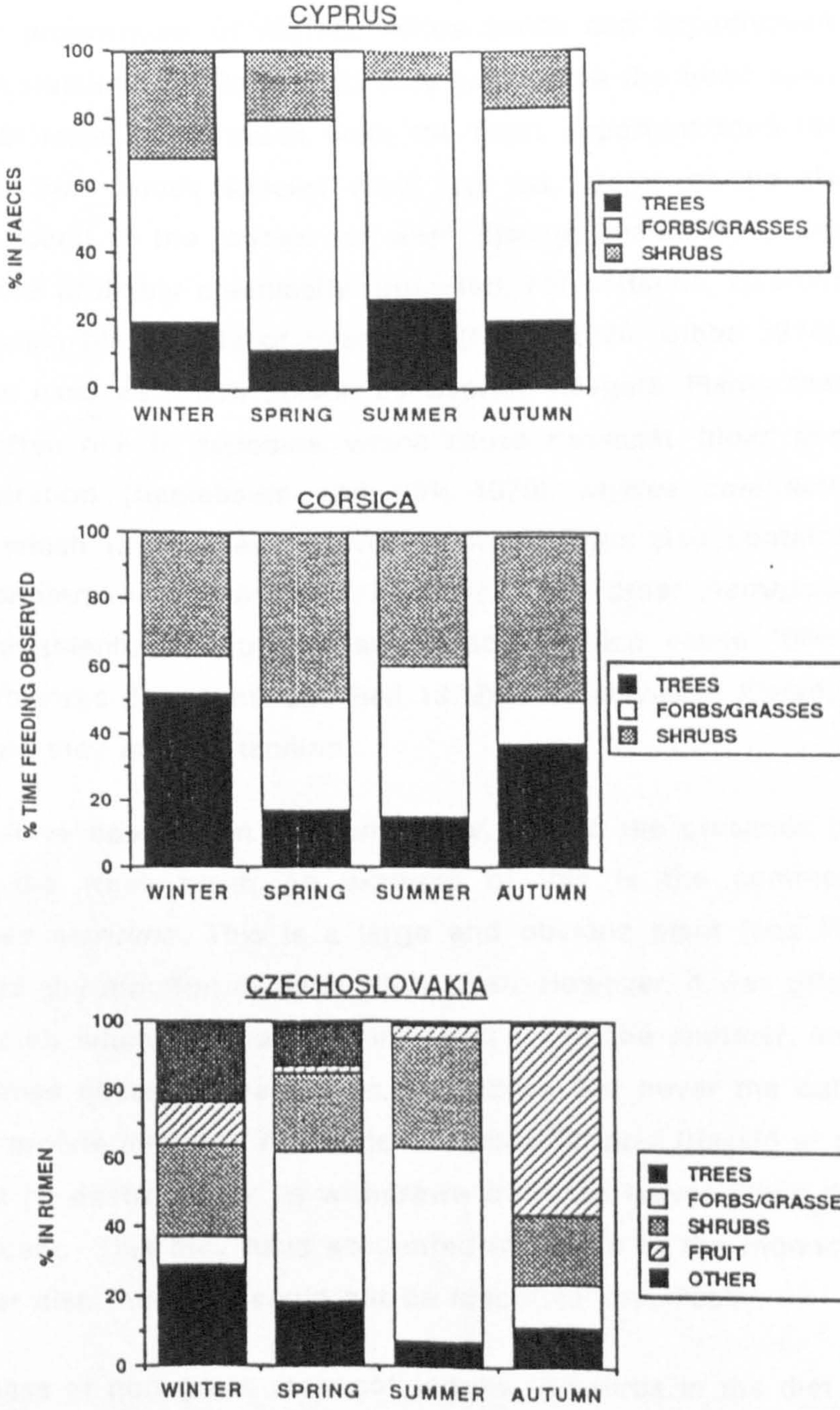


Fig 4.13

Estimated proportions of food types in the diet of mouflon from Cyprus (this study), Corsica (Pfeffer 1967) and Czechoslovakia (Mottl 1960).
Methods used: Faeces analysis in Cyprus; observation in Corsica; rumen content analysis in Czechoslovakia.



4.4 DISCUSSION

Like other wild and domestic sheep studied, Cyprus mouflon ate mostly plants of the herb layer (grasses, forbs, and non graminaceous monocots.) Faeces analysis is known to underestimate the intake of highly digestible species and to overestimate less digestible species (Bullock 1985, McInnes et al. 1983, Stewart 1967, Todd and Hansen 1973). Therefore the proportion of the diet composed of forbs (which were more digestible than shrubs or broadleaves: see Chapter 3) may have been higher than indicated in the faeces analysis. Similarly, the proportions of shrubs, *Pinus brutia* and broadleaved trees may have been overestimated. This would only accentuate the trend seen already in the data: that forbs and grasses were the most important food for mouflon in Cyprus and that woody species were less so. Some of the six species that were not found in the faeces but were distinguishable from the reference collection were probably chemically protected. For instance, *Quercus spp.* are known to contain high levels of phenolics (Feeny 1970, Gibbs 1974), and *Styrax officinalis* is used as a fish poison by Cypriot villagers. Plants that are fish poisons are often rich in saponins, which cause ruminant 'bloat' and may also affect respiration (Applebaum and Birk 1979). *Myrtus communis* contains volatile oils which may deter herbivory, *Cedrus libani* also contains aromatic oils and monoterpenes. *Astragalus lusitanica*, like other *Astragalus* spp., is likely to have selenium-containing amino acids which cause "blind staggers" in range herbivores (Rosenthal and Bell 1979). The leaves of *Platanus orientalis* are tough and may contain tannins.

Some plants may have been eaten only when dry, due to the presence of toxic compounds in the fresh plant. An example of this is the common monocotyledon *Urginea maritima*. This is a large and obvious plant (see Fig 1.4), that never showed any mouflon damage while fresh. However, it was often seen to have been eaten when the leaves were dried up in the summer, and mouflon were sometimes observed feeding on the leaves, but never the bulb. This plant contains a proline inhibitor, Azetidine-2-carboxylic acid (Hassid et al. 1976) which may well be destroyed or be withdrawn from the leaves when the plant becomes senescent. This may have accounted for some of the monocot portion of the summer diet, though it could not be identified specifically.

The general increase of non-grass monocotyledons and forbs in the diet in the summer may reflect the declining quality and/or availability of grasses in

the dry part of the year. Certain plants which are not ephemeral, and remain green during the dry months such as *Cistus* and *Lithodora*, were in lower quantities in the faeces during the dry season, and this could indicate their nutritional quality at this time (Chapter 3). During the late autumn and winter the animals appear to be eating a more varied diet than in the dry season. For instance *Lithodora, Cistus* and *Teucrium* appeared to be eaten in higher quantities during the rainy season than in the summer.

The similarities and differences between valleys were notable. Vroisha and Ayia shared some common patterns in the components of the faeces collected from them. Forbs, non-grass monocots, *Asphodelus* and *Cistus* content were similar in these two valleys. These two valleys were covered with mature *Pinus brutia* forest with an understorey of *Cistus* spp., and smaller clearings where grazing was available (Chapter 2). Pia valley resembled these first two both for *Asphodelus* and broadleaves, but there was much less pine or *Cistus* in the faeces in Pia, and more grasses. Pia was a more open area, with some pines but also with much maquis vegetation and a few areas planted with fodder (Cereals and alfalfa) by the Forestry Department. The periphery of the forest was within a few kilometres , so the faeces contents may have indicated a certain amount of use of agricultural areas. Limnitis and Ayios Mercurios, sampled only in the summer months, showed some similarities. Little or no *Teucrium, Rubus, Cistus, Pinus*, or *Lithodora* was ever found in the faeces from these valleys, and monocot levels were higher in Limnitis and Ayios Mercurios than in the other valleys. The amounts of pine and broadleaved trees eaten in Ayios Mercurios were similar to that in Ayia. *Pistacia terebinthus* and *Trifolium clypeatum* values for Limnitis were much lower than in other valleys whereas Ayios Mercurios did not differ greatly. Limnitis was a valley that had been burned by forest fire in 1974, and there were many open areas where a diverse ground flora could grow without being shaded out. Ayios Mercurios was a semi-open pine forest area with some fodder-planted areas.

Smaller differences between broad categories such as grass, forb and monocot might be expected than between different species of food plants. However even in such a broad category as grasses it seemed that there were real differences in the amount of grasses found in the faeces in Pia valley and that found in the two mature pineforest areas- Vroisha and Ayia. Similarly, the low amounts of pine in the faeces from Pia, Limnitis, and Ayios Mercurios could reflect the structure of the vegetation in these areas. It is possible that animals

pick up pine needles whilst eating ground layer vegetation. In the less heavily forested valleys, there were fewer areas that are overhung with pine trees. Thus animals would not pick up so much pine litter while feeding. Living pine needles contain monoterpenes which may deter herbivores from feeding on the needles in any quantity (Robinson 1979). Less *Cistus* appeared in the faeces from Pia than from Ayia or Vroisha, and this could reflect the greater choice of food in that valley than in the mature forest.

The only other quantitative published results of mouflon diet are those of Pfeffer (1967) and Mottl (1960). Pfeffer examined the feeding habits of mouflon in Corsica, in maquis habitat that had been burned seven years before his study. Mottls' study was on Corsican mouflon that had been introduced into Czechoslovakia. The Czechoslovakian habitat comprised areas of pasture, conifer belts and deciduous woodland. Pfeffer quantified his results by recording the number of occasions that mouflon were seen feeding on particular plants. However he did not record whether or not mouflon were feeding at night. In summer, mouflon may feed on certain plant groups at night when they contain more moisture (Meidner and Sheriff 1976, Sutcliffe 1979); and in order to avoid high temperatures during the day. Night feeding may therefore be underrepresented in Pfeffers' data. Mouflon in Cyprus certainly fed at night (Chapter 8) when, however, it was not possible to see what they were eating. Therefore faeces analysis is likely to have been more representative of the diet than observations of feeding limited to the daylight hours.

Rumen analysis has also been shown to be a valid quantitative method of determining feeding habits (Kessler et al. 1981, McInnis et al. 1983, Todd and Hansen 1973) because it too has the advantage that if the animals are feeding nocturnally, there is no loss of information. Mottl examined the stomach contents of 67 animals, and the results from Pfeffer, Mottl, and this study are included in Appendix 7. These results are presented graphically in Fig 4.13. Although Mottl states that the main food of mouflon in Czechoslovakia was forbs and grasses, mouflon in Cyprus ate more grasses and forbs throughout the year than did those in Corsica or Czechoslovakia. Cyprus mouflon also ate less shrubs, except in winter. A third of the diet of the Czechoslovakian mouflon was composed of trees in the winter, 18% in spring, least in summer and autumn (7–11%). The pattern was different in the Cyprus animals; the summer diet had the largest proportion of broadleaves (20%), the spring the least (7%). In Corsica, however, Pfeffer states that there was snow cover

during part of the winter, forcing the animals to feed on broadleaves (mostly *Arbutus unedo*) which he estimated comprised 52% of their diet in winter. Mouflon in Cyprus were never observed to feed on *Arbutus andrachne*, although it is a fairly common tree in the Paphos forest. However, because *A. andrachne* could not be specifically identified in the faeces, it is possible that this plant comprised part of the broadleaved tree fraction of the diet. In Cyprus, local forestry workers said that mouflon ate *A. andrachne*. However, there may have been an error in Pfeffers observational data in that it is much easier to see a browsing animal than a grazing one purely because the head is raised when browsing. Therefore more sightings may have been made of browsing mouflon than of grazing ones, leading to a bias in favour of browsing records.

The altitude of the mouflons' habitat in Corsica was all above 1000m, whereas that in Cyprus was all below 1300m, and snow did not lie for more than a day or two. In Czechoslovakia, winter is the time of poor forage availability, due to plant senescence and to snow cover rendering ground layer plants less accessible. In Cyprus, with its Mediterranean climate, summer is the season when the lack of rainfall causes many of the ground layer plants to dry up, reducing their availability and nutritive value. (Chapter 3). The apparently opposite seasonal trends in diet between Cyprus and Czechoslovakia can be seen as solutions to the same problem; that of utilising the available food resources.

The shrub component of the diet in Corsica was larger than that of the Cyprus mouflon. In Cyprus, shrubs (mostly *Cistus, Teucrium kotschyanum* and *Lithodora hispidula*) were consumed least in the summer (9%) although 21–33% were eaten in the winter and in spring; in Corsica 40% of the diet was composed of shrubs in the summer, 50% in spring, and 37–49% in autumn and winter. On the whole, then, the Corsican animals depended heavily on shrubs and on broadleaved trees, whereas the Cyprus mouflon depended more on grasses and forbs, even though both live in a Mediterranean climate. Pfeffer states that there was little *Cistus/Asphodelus* habitat type in the Bavella reserve, where his study was carried out, but that most of the maquis-type vegetation is *Arbutus* and *Cytisus*. Most of the forest floor in Cyprus had a great deal of *Cistus/Asphodelus* ground cover.

The preferences of foods can be ascertained by comparing the amount of

foods eaten with their availability in the environment, using a preference or electivity index, and this can shed more light on why certain foods appear more often at some times than at others, or in certain areas rather than others. This will be examined in Chapter 6.

4.5 Summary

1. Mouflon diet was investigated using faecal analysis, carried out on samples of mouflon faeces collected throughout the year from several different valleys.
2. Eleven different plant categories could be distinguished in the faeces. A further six plants could be identified from the reference collection but did not appear in the faeces.
3. The three major components of the faeces were grasses, forbs, and non-graminaceous monocotyledons.
4. In all months of the year except for January and November, forbs comprised over 20% of the fragments identified in the faeces. Grasses comprised 15-27% except late spring and early summer, when levels were lower, and non-grass monocots a further 10-30% except in winter.
5. Thus, the three categories combined comprised 38-82% of the fragments in the faeces in each month of the year. In the dry season months, from April until October, these three categories made up more than 57% of the total.
6. Other plant categories varied more between valleys and between months. Certain plants such as shrubs were eaten mainly in the wet season, although they were not ephemerals.
7. Valleys differed in some respects: it is suggested that this is due to the vegetation structure differences between them.
8. This feeding regime is compared with a study of the diet of mouflon in Corsica, which fed mostly on shrubs and broadleaved trees. A study of the diet of mouflon in Czechoslovakia is also examined, and although the shrub component of their diet was similar to that of the Cyprus animals, they had more seasonal variation in the grass and tree components of their diets. These are discussed with reference to season.

CHAPTER 5
DIET QUALITY

5.1 INTRODUCTION

Due to the Mediterranean climatic regime in Cyprus, poor quality forage was available to mouflon during the dry season (Chapter 3). Although the bulk of the diet was composed of plants of the herb layer (grasses, forbs and non-graminaceous monocots), the mouflon fed more on broadleaved trees in the dry season than at other times of the year (Chapter 4). During the dry season, broadleaved trees had a higher crude protein content than other plants (Chapter 3). Therefore it is possible that the mouflon were using these trees as a protein source when little was available elsewhere. The quality of the mouflon diet could be investigated using faecal indices of nitrogen content.

It is known that sheep require 5-8% crude protein in their diet to maintain nitrogen balance (ARC 1965, NRC 1975, and see Chapter 3). Crude protein content of faeces has been shown to be a good indicator of diet quality for ruminants (Arnold and Dudzinski 1963, Bryant et al. 1983, Holechek et al. 1982a, Klein and Schonheyder 1970, Owen-Smith and Novellie 1982, Putman 1984, Walker et al. 1975). Faecal indices of diet are especially useful when relative differences over time rather than absolute values are of primary concern (Holechek et al. 1982a).

Because the Cyprus mouflon is an endangered species, it was necessary to use a method of diet quality analysis that did not disturb or harm the animals. Therefore, as in the quantitative diet analysis (Chapter 4), faecal nitrogen determination was an appropriate method. Nitrogen content of the diet has been shown to be linearly related to nitrogen content of faeces in many species of ruminant; for instance elk *Cervus elaphus* (Mould and Robbins 1981), roe *Capreolus capreolus*, sika *Cervus nippon* and fallow deer *Dama dama* (Putman and Hemmings 1986), some other cervids (Leslie and Starkey 1985), cattle and sheep (Bredon et al. 1963, Erasmus et al. 1978, Holechek et al. 1982a, Wofford et al. 1985), and East African bovids (Arman et al. 1975, Sinclair 1977) as long as there are not high levels of soluble phenolics in the diet (Wofford et al. 1985).

Most faecal nitrogen is metabolic nitrogen which comprises microbial cell wall from the rumen (Mason 1969, Van Soest 1982). The amount of bacterial nitrogen is largely determined by the level of intake of fermentable energy (Mason 1969) and therefore provides an indirect measure of crude protein intake due to the relationship between digestible energy and crude protein content (Bredon et al 1963).

5.2 METHODS

To investigate how variable individual pellet groups were likely to be in terms of their nitrogen content, eleven different pellet groups from the same valley and month (Vroisha, August) were individually analysed, using the same micro-Kjeldahl method as for the plant samples. (Table 5.1). The mean crude protein content was 12.81 with a standard error of 0.90, which was considered an acceptable error. Running means were calculated for this data (Fig 5.1) and they stabilised at about n=6. The composite faeces samples (See Faeces analysis) were then similarly analysed for nitrogen content. The values obtained were then multiplied by 6.25 to give the crude protein content of the faeces (AOAC 1984).

Various equations have been offered for relating crude faecal protein or faecal nitrogen to dietary protein or dietary nitrogen. These include:

DP=(1.677xFP)-6.93 (Bredon et al. 1963, cattle);
DP=(2.610xFP)-11.9 (Sinclair 1977, blue wildebeest *Connochaetes taurinus*)
DN=(0.662xFN)-0.09 (Hinnant 1979, steers i.e. male cattle).
DN=(0.789xFN)-0.11 (Hinnant 1979, cows).
DN=(0.795xFN)-0.14 (Raymond 1948, sheep).
DN=(0.851xFN)-0.281 (Holechek et al. 1981, cattle.)

where DP=dietary protein content,
FP=Faecal protein content,
DN=dietary nitrogen content,
FN=faecal nitrogen content.

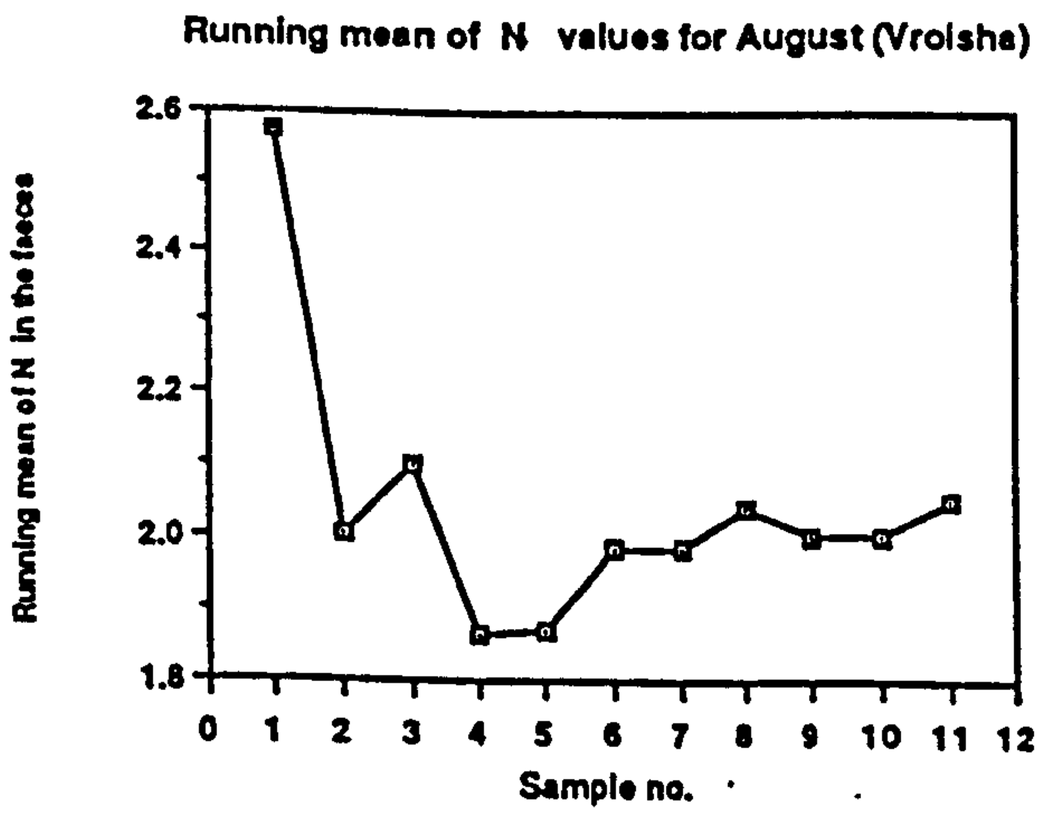
The equation of Raymond (1948) was used on the results of the nitrogen analysis for mouflon, because it was devised for sheep.

Table 5.1
Percent of nitrogen and crude protein (N x 6.25) in the individual faecal pellet groups collected in August in Vroisha valley.

Sample no.	% nitrogen	% crude protein
1	2.58	16.10
2	1.44	8.98
3	2.29	14.32
4	1.16	7.28
5	1.88	11.73
6	2.57	16.09
7	1.97	12.33
8	2.41	15.07
9	1.71	10.66
10	1.99	12.47
11	2.55	15.92
Mean±standard error	2.05±0.14	12.81±0.90

Fig 5.1

Running means of the nitrogen content data presented in table 5.1



5.3 RESULTS

5.3.1 Protein in the faeces

At no time did the percent of crude protein content of the faeces fall below 7% (Table 5.2). The upper limit was 14% (Vroisha, in February). Protein content of the faeces varied throughout the year in a similar pattern for each valley. The general pattern was that of high levels (over 10%) from February until early or late summer, (depending on the valley) which dropped during late summer and autumn to levels around 7-9%; levels rose again after that, in December and January to 10-11% (Fig 5.2).

5.3.2 Protein in the diet

When the Raymond (1948) equation was applied to the results, it appeared that the estimated crude protein level intake fell below 7% on the following occasions:

Ayia in January, August, September, November, December;
Pia in August, September, October, November, December;
Vroisha in June and September;
Limnitis in August;
Ayios Mercurios in September.

but only below 5% in October in Pia valley. (Table 5.2, Fig 5.2).

5.4 DISCUSSION

Although high levels of phenolics in the diet can distort faecal protein values, this is less important for grazers that are primarily feeding on grasses (Green 1987, Holechek et al. 1982a, Mould and Robbins 1981). This is because grasses do not usually produce tannins (Cooper and Owen-Smith 1986). In addition, only 15% of annual and herbaceous perennial dicot species were found to contain tannins as opposed to 80% of woody perennial dicot species (Bate-Smith and Metcalf 1957, Rhoades and Cates 1976). The mouflons' diet, as seen from the faeces analysis, was composed mainly of grasses, forbs, and non-graminaceous monocots, none of which were likely to contain high levels of phenolics. Therefore it is unlikely that the faecal protein values were much distorted by phenolic content.

Table 5.2

Nitrogen and crude protein content of the faeces.

An estimate for dietary crude protein is also shown using the equation from Raymond (1948): Dietary crude protein=[(faecal nitrogen x 0.795)-0.14] x 6.25

Valley	Month	% nitrogen	% crude protein (% N x 6.25)	Raymonds'estimate for dietary crude protein
Pia	February	1.85	11.55	8.31
	March	2.18	13.64	9.97
	April	2.11	13.17	9.60
	June	1.80	11.25	8.07
	August	1.50	9.40	6.60
	September	1.48	9.27	6.49
	October	1.15	7.19	4.84
	November	1.27	7.94	5.44
	December	1.43	8.91	6.31
Ayios Mercurios	April	1.90	11.86	8.56
	May	1.90	11.87	8.56
	June	1.60	10.02	7.09
	September	1.54	9.64	6.79
Limnitis	May	1.98	12.37	8.96
	June	1.83	11.46	8.22
	August	1.46	9.12	6.37
Ayia	January	1.39	8.68	6.03
	February	1.81	11.33	8.13
	March	1.82	11.40	8.19
	April	1.76	11.00	7.87
	May	2.01	12.54	9.10
	June	2.10	13.14	9.57
	July	1.77	11.07	7.93
	August	1.44	8.99	6.27
	September	1.38	8.61	5.97
	November	1.28	7.98	5.47
	December	1.57	9.79	6.91
Vroisha	January	1.86	11.63	8.37
	February	2.25	14.09	10.33
	March	2.22	13.86	10.14
	April	2.08	12.99	9.45
	May	1.76	11.01	7.88
	June	1.51	9.46	6.65
	July	1.86	11.63	8.37
	August	1.98	12.39	8.97
	September	1.52	9.50	6.68
	November	1.86	11.63	8.37
	December	1.86	11.62	8.37

Fig 5.2

Crude protein content of faeces (F) and estimated crude protein content of the diet (D). D was estimated by Raymonds' (1948) equation: D=(F x 0.795)-0.14. The 5% and 7% levels are indicated (——) as the minimum threshold for nitrogen balance for sheep (ARC 1975, Mould & Robbins 1981, NRC 1975), Robbins et al.1975)

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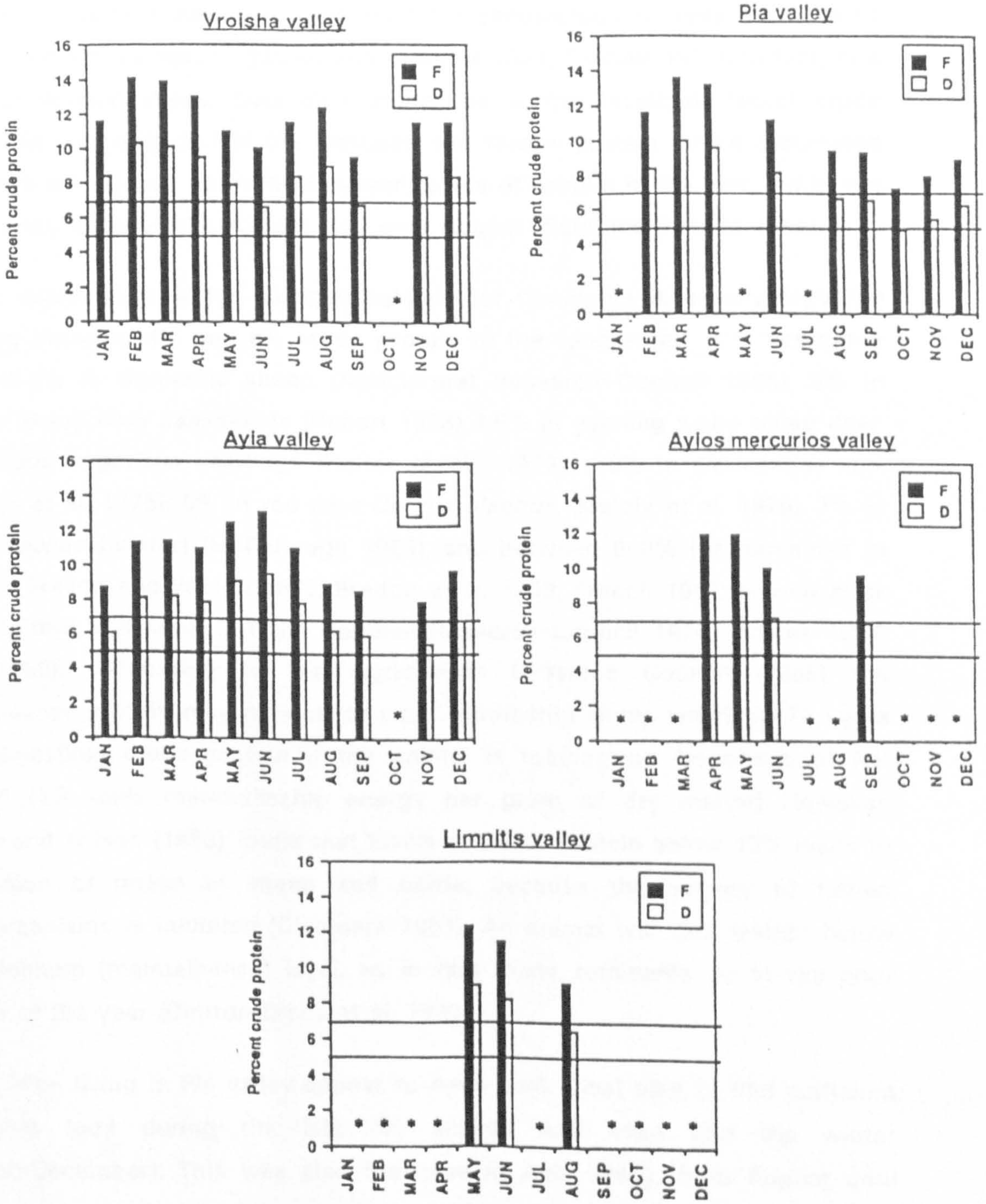


The growing season coincided with the highest faecal crude protein values in all valleys, and the months of lowest forage quality were associated with the lowest protein content of the faeces (August until November). The protein content of plants goes down in the dry season as the proportion of stem increases and the proportion of leaf decreases (Sinclair 1977); at the same time the overall protein content decreases in all components in the dry season. This was the case in the summer in Cyprus (Chapter 3). Faecal nitrogen is positively related to dietary nitrogen provided that it is above the minimum level for nitrogen balance, while below this it remains approximately constant because metabolic breakdown products from endogenous sources continue to be removed via the faeces (Mould and Robbins 1981, Sinclair 1977). In fact, in a study of Stones' sheep, *Ovis dalli stonei* the winter levels of faecal crude protein did not drop below 6% although the forage protein intake (estimated from food habits) was only 4%. However, levels of protein in the diet and in the faeces were linearly related from May until August (Seip and Bunnell 1985).

The minimum level for nitrogen balance for ruminants is usually regarded as being between 4% and 8% crude protein in the food eaten. It is estimated as 4.3-5.8% in domestic sheep (Agricultural Research Council 1965), 5% in bighorn sheep *Ovis canadensis* (Hebert 1973) 4.8% in yearling white tailed deer *Odocoileus virginiana* yearlings (Holter et al. 1979), 4.8% in *Odocoileus* spp. (Robbins et al. 1975), 5% in red deer *Cervus elaphus* (Maloiy et al. 1970), 7% in elk *C. elaphus* (winter) (McCullough 1969), and between 6-8% for ruminants in general (Bredon and Wilson 1963; Bredon et al. 1963; French 1957; French et al. 1957; Milford and Minson 1966; National Research Council 1970; Plowes 1957; Reid 1968). According to the Agricultural Research Council (1965) the maintainance protein requirement for adult (domestic) sheep weighing 70 kg. is 4.3% digestible crude protein if the animal is feeding on "roughage of fair quality" (1.8 kcals metabolisable energy per gram of dry matter) However, Blaxter and Wilson (1963) found that levels of crude protein below 13% leads to depression of intake in sheep and cattle, because the activity of rumen microorganisms is inhibited (Chalmers 1961). An animal will lose weight below the minimum (maintainance) level, as in fact many ruminants do in the poor season of the year (Clutton Brock et al. 1982).

Mouflon living in Pia valley appear to have been least able to find sufficient digestible food during the late dry season and even into the winter (August-December). This was also the case in Ayia valley, from August until

January, when the estimated diet protein was below 7%. If the maintainance threshold for mouflon is in fact 7%, then animals in Pia and Ayia were below maintainance, unlike those in Vroisha, the only other valley with year-round data. Although Pia appeared to have plenty of areas of open space where there were grasses and forbs, Vroisha also had some abandoned fields where the animals were seen to feed. However, the difference between these two areas could be explained by their topgraphical differences: Vroisha area is between 600-700m above sea level, and is a generally north-facing valley, with deep, shady watercourses; whereas Pia is at 400-500m, is less deeply dissected by streams, and has a more southerly aspect. The ground flora in Pia area dried up before that in Vroisha, rendering it less digestible. Ayia valley, although similar in topography to Vroisha, had fewer grassy clearings, and there may thus have been less digestible food available. This could have led to the poor diet quality in the most difficult part of the year. If, however, mouflon have a protein maintainance threshold of 5%, only Pia fell below this, and only in October. This would mean that the animals were less likely to be on or below the threshold for maintainance during the dry season than if the threshold is 7% dietary protein.

5.5 SUMMARY

1. The estimated mean crude protein intake was lowest from August until early winter when rainfall was low and the plant growth had more or less ceased.
2. Ayia and Pia valleys had lower levels of crude protein in the faeces than Vroisha. This is discussed with reference to altitude and aspect.
3. The estimated food protein level only once fell below 5%, (in October in Pia valley), which was one of the lowest published estimates for minimum maintainance in ruminants.
4. It seems that mouflon diet in the dry season may, in some valleys, be below the average level necessary for maintainance among similar-sized ruminants.

CHAPTER 6
FOOD SELECTION

6.1 INTRODUCTION

Having verified what the main plant types comprising mouflon diet were (Chapter 4), the degree of selectivity of the different foods could then be investigated. A selected food is one that appears in the diet in a higher percentage than that in which it appears in the environment. Cyprus mouflon had a wide choice of plants available to them from which to obtain their food (Chapter 2). Mouflon had no other congeners as competitors–the only other major mammalian herbivores in the Paphos forest were hares. Because Cyprus is a Mediterranean environment, the animals must cope with the situation where the summers are the worst time of the year. The results of the nutrient analysis, (Chapter 3) showed that food quality was lowest in the late summer and early autumn, when rain had not fallen for several months. In most of the other studies of sheep feeding habits, the winters were the time of poor forage and low temperatures, and the summer a time of plenty. In Cyprus, during the winter, plants were of high digestibility and often had high crude protein levels, affording good forage for the animals. The environmental stress faced in summer was that of high temperatures during the middle of the day, and of low water availability. Temperature stress was avoided by mouflon by resting in the shade during the hottest parts of the day, and feeding only during the morning and evening (Chapter 8).

Mouflon might be expected to select, where possible, for plants with a high moisture content during the dry season. Moisture was positively correlated with crude protein in all months except June (Chapter 3), so by selecting for moisture content (green, lush plants) mouflon would also obtain high dietary protein. Those plants with the highest moisture content during the dry season were the forbs, all the trees (coniferous and broadleaved), and *Teucrium kotschyanum*. Grasses and non-graminaceous monocots dried up during the summer to a much greater degree than the dicotyledonous plants. Sheep are known to select for green plant material before dry, and for leaf before stem (Arnold and Dudzinski 1978), which provide more digestible food.

Ruminants can be selective at some seasons and not at others. If there is

abundant forage available, some animals can afford to be selective; for instance deer (Westoby 1974) or sheep (Ellis et al. 1977, Grant et al. 1985, Milner and Gwynne 1974). As the food supply decreases, animals must eat less acceptable food or starve (Arnold 1964). A selection index should show whether or not Cyprus mouflon were being less selective during the time of poor forage than during the season of abundant, digestible food.

6.2 METHODS

Comparing the availability of different food types in the environment with the proportion of each type of food in an animal's diet can indicate which foods are avoided or preferred. Various preference indices, sometimes known as electivity indices, have been developed. Using the diets of fish as a basis, Ivlev (1961), developed a method of estimating electivity. The proportional abundance of each food in the diet (r) was divided by the proportional abundance of that food in the environment (p) to give Ivlevs' forage ratio. Another version was Ivlevs' electivity index for each food type, $E=(r-p)/(r+p)$ (Ivlev 1961).

Since then, other indices have been developed, all using Ivlevs' work as their basis, but all attempt to improve the linearity of the preference index over the full range of r and p, or its amenability to comparisons between sites. These indices were tested by Lechowicz (1982) who recommended the use of the Vanderploeg & Scavia (1979) E* index, which provides a possible range of preferences from plus one to minus one.

$$E^*=[W-(1/N)]/[W+(1/n)]$$

where N=number of different kinds of food items;
W=(r/p)/sum of all (r/p) for each food.

Plus one indicates that the food is present in the diet but not in the environment, minus one that the food is present in the environment but not in the diet. A zero value is obtained when the food is present in the diet in the same proportion as which it occurs in the environment. In fact, Lechowicz found that most of the different indices tested gave the same rank order of preferences. Errors can occur in Ivlevs' and other electivity indices when a food type is very rare or very abundant. The E* index minimises these errors but is still vulnerable to sampling errors for foods that are rare in the diet and

rare to only moderately common in the environment. However, unlike Ivlevs' index, E* is stable when there are changes in relative abundance of food types, such as occurs seasonally or between sites. Rank order comparisons from different sites can be carried out with the E* index, as long as each sample has the same food types (Lechowicz 1982). E* embodies a measure of a food's value as a function of both its abundance and the abundance of other food types present. It is supposed to minimise the errors occurring with rare foods or very abundant foods. Therefore the E* index was used in this study when preferences were calculated for the different mouflon food types. However, as is explained in the discussion, there are still problems when a food is recorded in the diet but not at all in the quadrats.

The E* preference index was calculated for each food type by valley and by month where p=the percent availability of each food type (see Chapter 2) and r=the percent frequency of each food type in the faeces. The E* values by month and by valley were then ranked in descending order of preference. Ranks are more easily interpreted than the absolute E* values themselves, as there may be inaccuracies in E* values of some food types, as indicated above. Also, because there was only one value per valley per month for each faeces analysis result, it was not known how variable each result was. However, because each faeces analysis value was taken from a composite sample of at least 10 different pellet groups, it was assumed that each result was representative of the diet at each time and place. The ranked E* values were used to compare mouflon diets between sites and seasons.

6.3 RESULTS

The preference indices are presented by food type and by valley in Appendix 6. In some cases, a food type did not appear in the quadrats (i.e. it was rare), but it was recorded from the faeces. E* could not be calculated properly if p=0. However, the principle of this index is that if a plant appears in the environment but not in the diet, it is totally avoided and the selectivity should be -1. If a food appears in the diet but not in the environment, it is totally selected for, and the selectivity should be +1. Therefore, if a food was found in the faeces and p=0, E* was assigned the value of +1. In the following section, note that the data for Ayios Mercurios only covers May, June and September, and that for Limnitis only covers May, June and August.

6.3.1 Forbs.(Fig 6.1)

Forbs were selected against in all months measured in all valleys except in August in Ayia and May in Ayios Mercurios. In Vroisha, forbs were more strongly avoided in November and December than during other months. The E* values for forbs were ranked between 5th and 8th in all months measured in all valleys except in Vroisha. In Vroisha, forbs were ranked much lower from January to April than in other valleys (between 8th and 10th), before rising to a peak in May and June (4-5) and then falling to 6-8 from July until December. In general, forbs were ranked highest in May or June, but there was not a great deal of seasonal variation except in Vroisha.

6.3.2 Grasses.(Fig 6.2)

Grasses were usually avoided, but were selected for on the following occasions: April in Pia, July in Vroisha, and August in Ayia. In Ayia, there was very little selection for or against grasses in July, September and November; this was also the case in Vroisha in January and February. Ranks tended to be higher in late spring or in summer than in autumn or winter, and tended to fall between 5 and 9. In Ayia, ranks were lowest in February, March and December (9th) and highest in July (4th), with the rest of the year falling between 5 and 8. In Pia, ranks were lowest from September to December (8-9th) and in June (9), 6-7th in February, March, and August, and highest in April (5th). In Ayios Mercurios grasses ranked 8-9th; and in Limnitis between 5-7. In Vroisha all months ranked between 5 and 7 except May (2) and June and September (8th).

6.3.3 Non-grass monocotyledons.(Fig 6.3)

Monocots were selected for and ranked highly in all valleys, except for Ayia valley from January to April, when there was avoidance, or in the case of March, weak selection, and ranks were lower (5-10). Otherwise, ranks in Ayia were 2-4; in Vroisha 1-4; in Ayios Mercurios 3-4; in Limnitis 2-4; and in Pia 2-5 (mostly 2-4). Monocots tended to be more highly ranked in late spring and in early summer than at other times of the year.

6.3.4 *Cistus spp.* (Fig 6.4)

Without exception, *Cistus* spp. were always avoided, and usually ranked between 8th and 11th. They were less strongly avoided and ranked more highly from January until March in Ayia; and from January to April in Vroisha than

during the rest of the year. In Ayia, they ranked 5th–6th in January and February. They rarely comprised a large proportion of the diet except in spring in Vroisha, (13–18%) and during winter and spring in Ayia (10–20%).

6.3.5 *Lithodora hispidula*.(Fig 6.5)

In Vroisha *Lithodora* was selected for in February and in April, and avoided during the other months of the year. It ranked highest in April (1) and lowest in June and July (8–9th); and between 4–7 in the other months. In Pia it was selected for from October until April, when it ranked 4–7th, but avoided from June to September, and ranked 7–11th. In the months measured in Ayios Mercurios, most of the year in Ayia, and in August in Limnitis, the E* values were +1, because it was found in the faeces but not in the quadrats. In Ayia, it was only recorded in the quadrats in June and July, when the value of the E* showed avoidance, and were ranked 8–9th. Ranks were between 1 and 2 on the occasions where E*=+1. In Limnitis it was neither recorded in the quadrats nor in the faeces in May or June.

6.3.6 *Teucrium kotschyanum*.(Fig 6.6)

This species was avoided all year in Vroisha, but selected for all year in Ayia. In Ayia, selection was less marked from late summer until December than during the rest of the the year, and ranks were 3–4 from January to July, and 5–7 from August to December. Avoidance was less strong from January until March in Vroisha than during the rest of the year; but *Teucrium* was ranked from 7–10 in most months except March (5th) and June (4th). In Pia from October until April, in all of Ayios Mercurios, and in Limnitis in May, the E* values were +1 because *Teucrium* was never recorded in the quadrats but it appeared in the faeces (although usually in very low amounts: less than 2%, except for Pia from November until February, when it comprised 6–9%). Ranks were therefore high (1–3) in the cases where E*=+1. In Pia in June, *Teucrium* was slightly avoided and was ranked 5th; and in August was slightly selected and ranked 3rd. In Limnitis in June it appeared in the environment but not in the faeces, so was highly avoided, and it ranked 9th. The top shoots of most of the *Teucrium* plants encountered by the observer had been eaten.

6.3.7 Broadleaved trees. (Fig 6.7)

In Ayia valley there was consistent avoidance of broadleaved trees, where they formed only a small part of the diet (less than 10%); they were ranked 8th–10th in all months except March, when they ranked 11th. In Pia valley broadleaved trees were strongly avoided only in February and in March, when they ranked 10.5. They were either slightly avoided (October), or selected for during the rest of the year (April–December), and ranked between 5–7 except June (3rd). In Ayios Mercurios broadleaves were slightly selected for and ranked 5–6. In Limnitis, they were slightly selected for in May and in June, but in August they were not recorded in the quadrats but appeared in the faeces, so E*=+1. Ranks in Limnitis were between 2 and 4. Finally, in Vroisha, E*=+1 from January to March and in July, because broadleaves were not recorded in the quadrats; and the ranks for these months were 1–2. Broadleaves were in the quadrats in all other months, and were selected for in April, November, December (ranks=2–4), and avoided in May and in June (ranks were 7 and 3).

6.3.8 *Asphodelus aestivus*. (Fig 6.8)

In Ayia, *Asphodelus* was avoided from January until August, and selected for from September until December. (In September E*=+1). It ranked highest in September (2) and lowest from January to May and in August (8–10th), and ranked 4–6th during the rest of the year. In Pia it was not eaten from February until June, nor in October, so was totally avoided, and ranked 10th–11th; in other months it was slightly selected for and ranked 4–7th. In Limnitis it was avoided in the months measured, and ranked 5–8; in Vroisha it was avoided from March to July, and in December, and selected for from September until February (excluding December). It was ranked highest in Vroisha in September and November (2–3); lowest in March (10th) and between 4–7 in the other months. In Ayios Mercurios, it was not recorded in the quadrats in May and September, but was eaten in June and September, giving an E*=+1 value and a rank of 2 to September, and 3 to June.

6.3.9 *Pistacia terebinthus* and *Trifolium clypeatum*. (Fig 6.9)

This category was avoided in Limnitis in the months measured, when ranks were 7, 4 and 9 (in May, June, and August). However, it was selected for in the months measured in Ayios Mercurios, where ranks were 4–6. In Ayia it was avoided from April until July, and selected during the rest of the year. In March

and August, E*=+1, and it ranked 2nd. Of the other months in Ayia, ranks were lowest in June, July and September (6-7) and were 3-5 the rest of the year. From September to April in Pia it was not recorded in the quadrats, but appeared in the faeces (between 2-7%), thus giving E* a value of +1. It ranked 2-3 in these months. In June and in August it appeared in the quadrats, and was calculated to be avoided, only slightly in June (ranked 4th), but more so in August (ranked 9th). In Vroisha, this category was in the faeces but not in the quadrats from November until February, so was highly selected for (E*=+1), ranks being 1-1.5. However, it was also selected for during the rest of the year except for May and September; ranks were 2-5 from March-September.

6.3.10 *Pinus brutia*. (Fig 6.10)

Although this tree was never a major component of the diet (always less than 7%, usually less than 4%), it appeared highly selected for in Ayia because in that valley, most of the pine trees were mature, without many low hanging branches, and the quadrats only included pine once, in April. However, it appeared in the diet in small quantities in each month. Ranks in Ayia were correspondingly high (1-2). This was never the case in the other valleys-pine was always recorded in the environment, and was avoided strongly in Ayios Mercurios and in Pia all year (ranks=8-11), and in Limnitis (ranks=8-9.5). It was also avoided from May to January in Vroisha (except for July) and slightly selected for from February until April. It was ranked 9-10th from September to December, 3rd in March, April and July, and 6-9th in the other months of the year.

6.3.11 *Rubus sanctus*. (Fig 6.11)

This species was consistently avoided in all valleys in all months, and usually ranked 11th (9-11th in Ayios Mercurios), with the following exceptions: March in Ayia, when there was slight selection and it was ranked 5th; March and June in Pia when it was recorded in the faeces but not in the quadrats, so E*=+1 and ranks were 1-2; and the rest of the year in Pia, all months measured in Limnitis, and September in Vroisha, when it was neither recorded from the faeces nor from the quadrats.

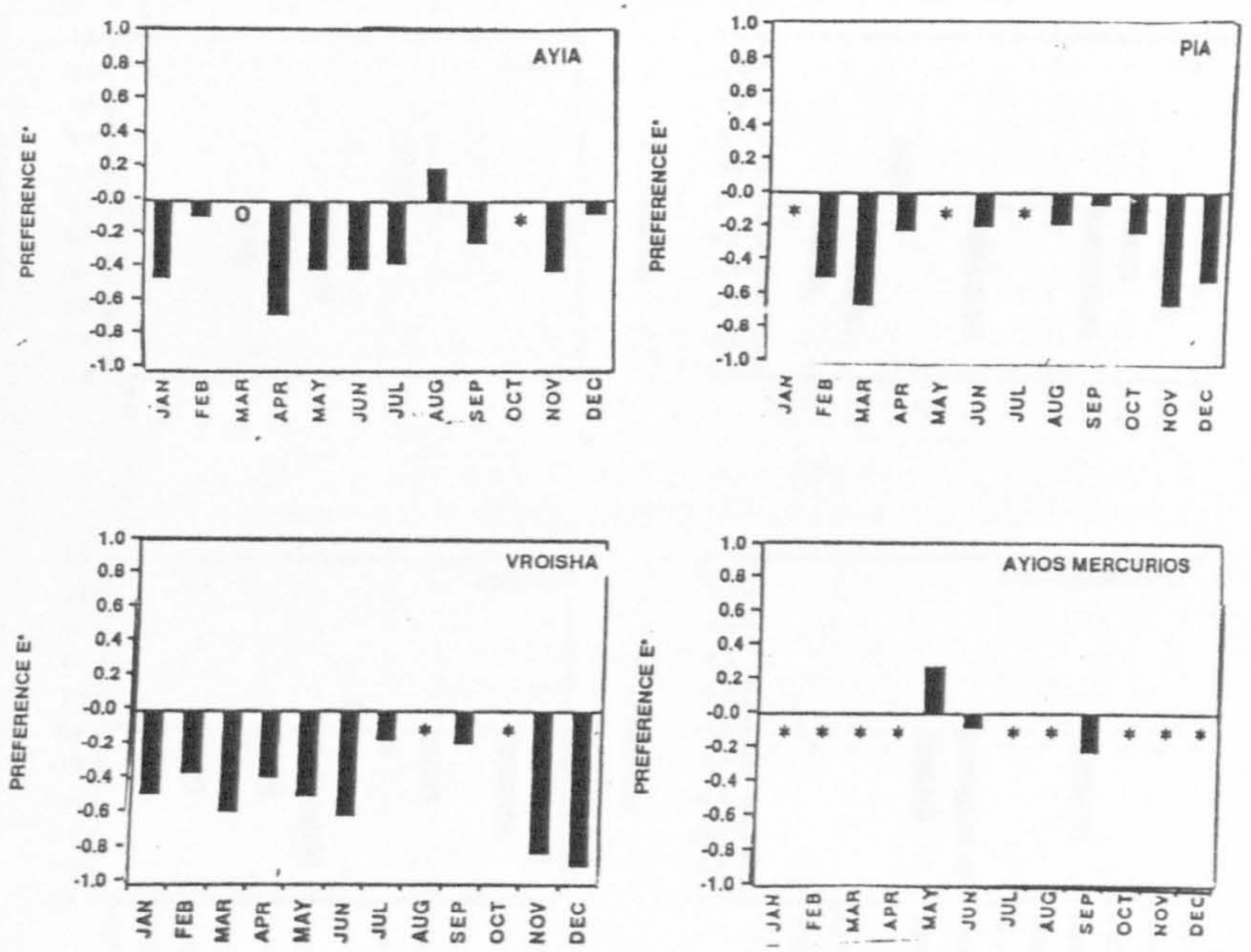
Fig 6.1

Preference index E* for forbs.

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS (AYIOS) AND LIMNITIS.

E*=[W-(1+N)] where N=no. of different kinds of food; W= $\frac{r+p}{\text{sum of all } r+p}$;
[W+(1+N)]

r=percentage frequency of each food in the diet; p= percentage frequency of each food in the environment. No data=*. 0=E* was equal to zero.



RANK OF THE E* VALUES FOR FORBS.

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS (AYIOS) AND LIMNITIS.

Calculated by ranking the E* values for all the food types in each month in descending order. i.e. a rank of 1 means the food was the most preferred during that month. No data=*

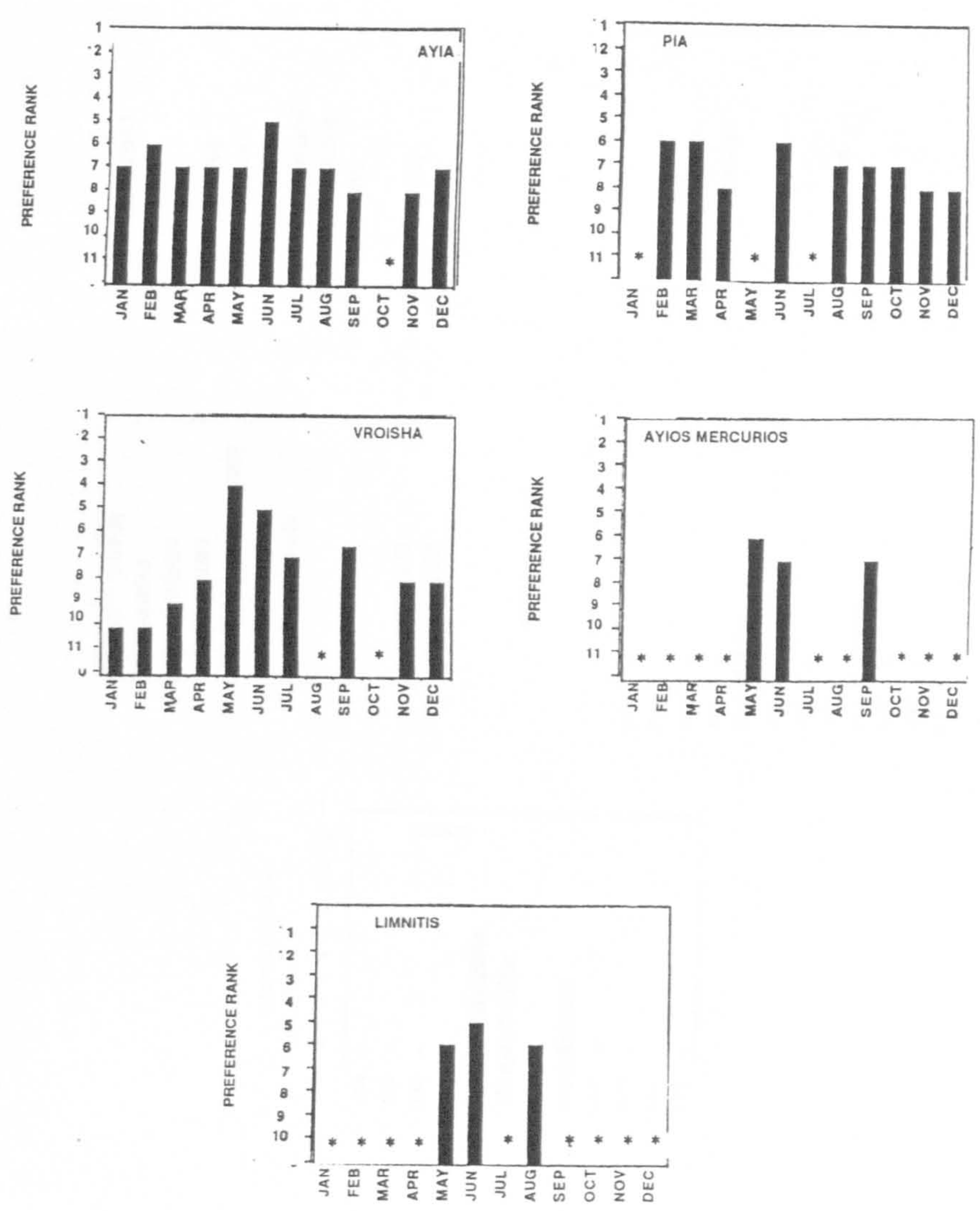
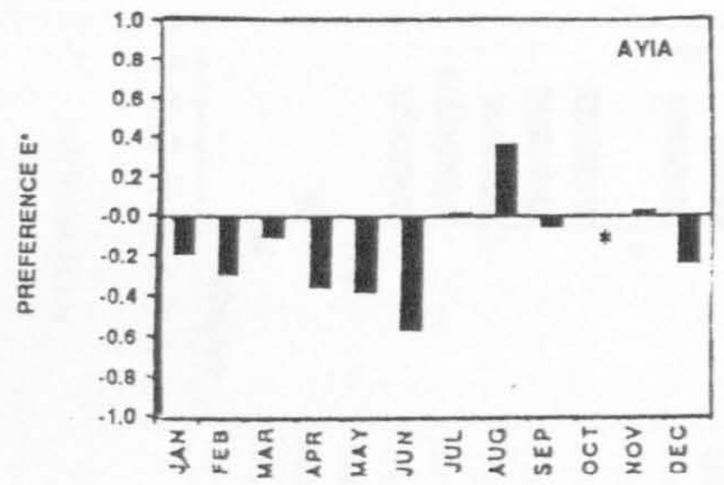
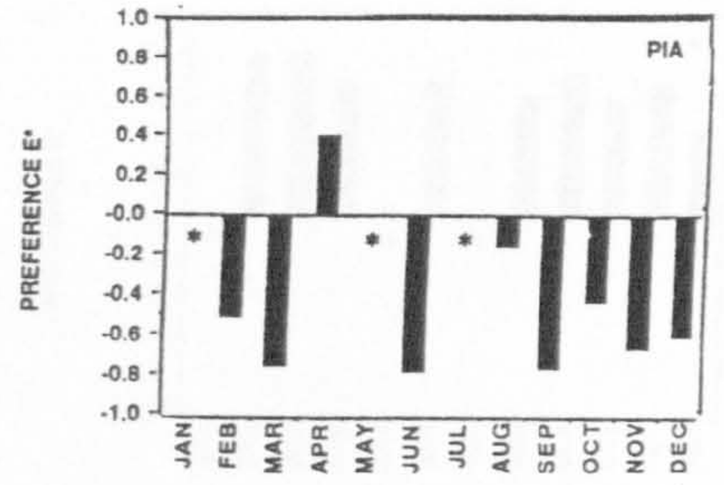


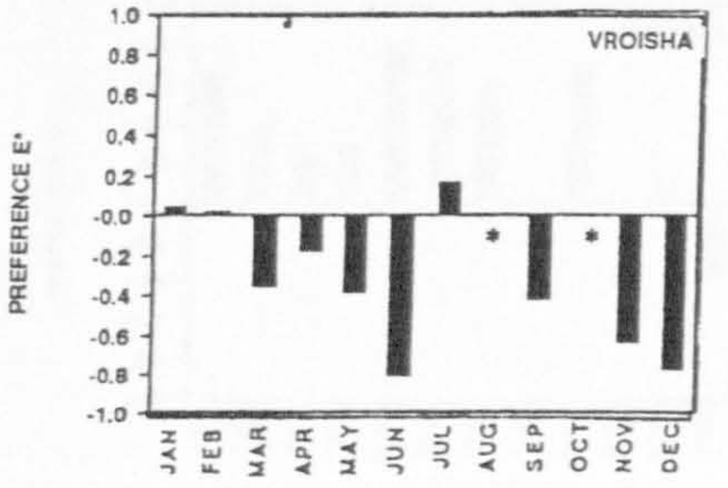
Fig 6.2

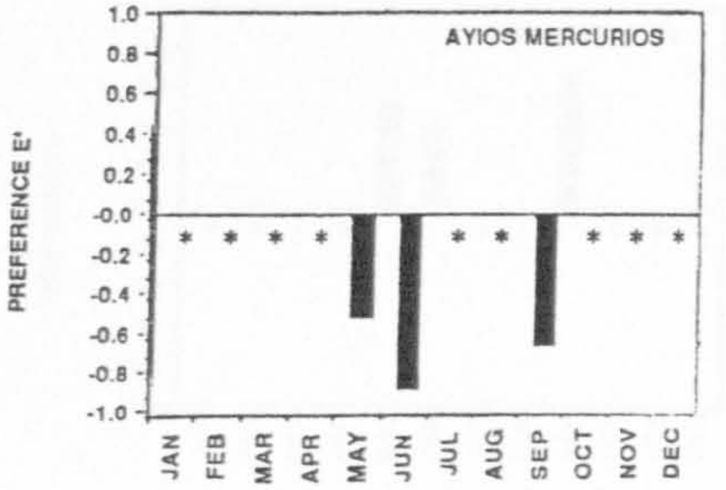
Preference index E* for grasses.

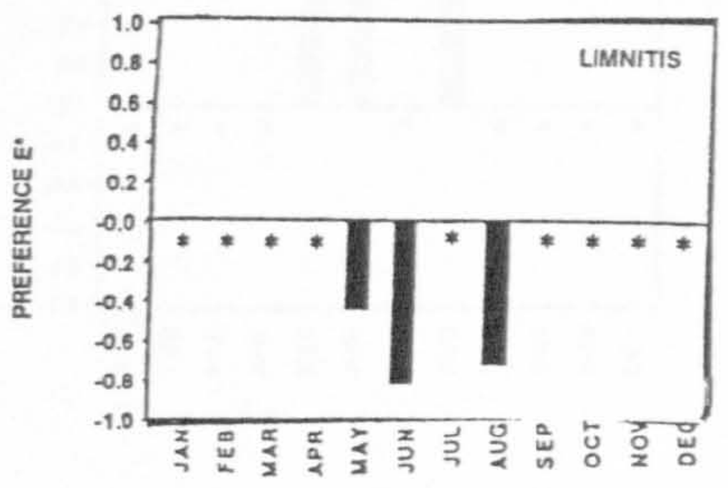
For the valleys of AYIA, PIA, VROISHA, AYOS MERCURIOS (AYIOS) AND LIMNITIS.
E*=[W-(1+N)] where N=no. of different kinds of food; W= $\frac{r+p}{\text{sum of all } r+p}$;
[W+(1+N)]
r=percentage frequency of each food in the diet; p= percentage frequency of each food in the environment. No data=*.





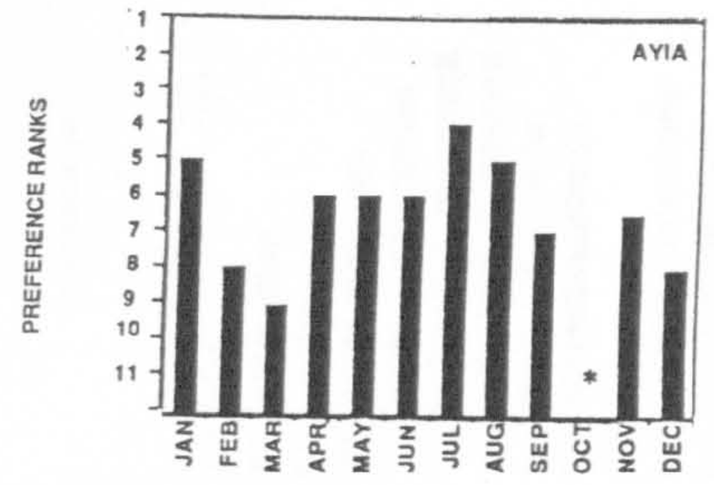


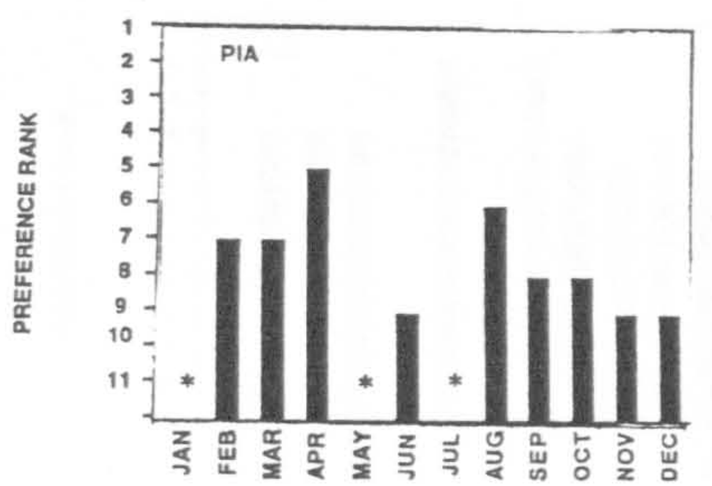


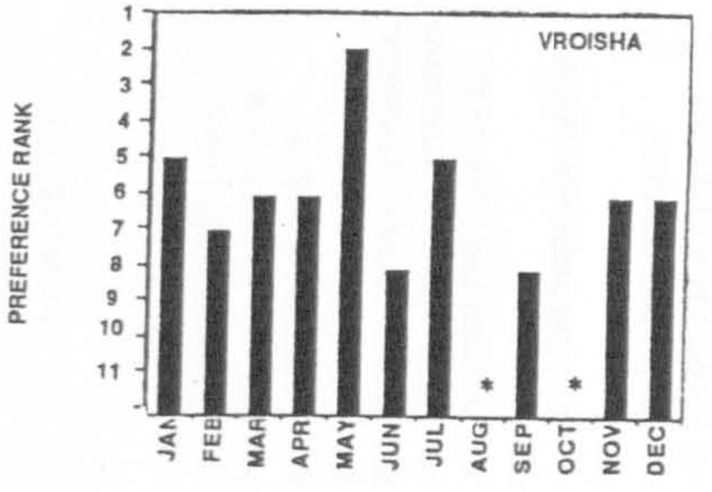


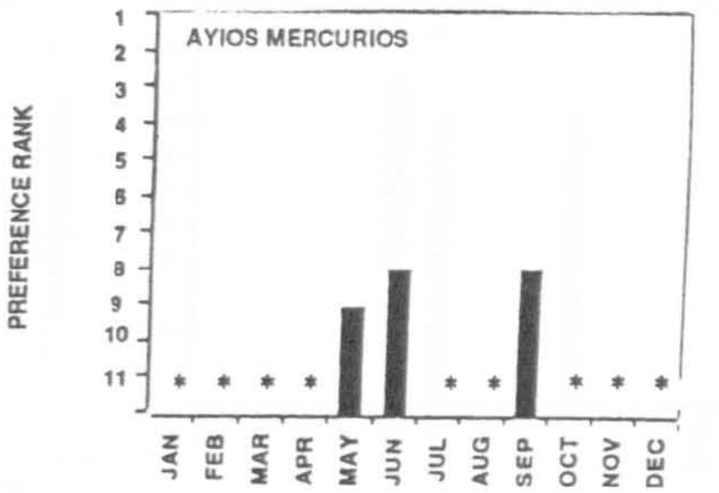
RANK OF THE E* VALUES FOR GRASSES.

For the valleys of AYIA, PIA, VROISHA, AYOS MERCURIOS (AYIOS) AND LIMNITIS.
Calculated by ranking the E* values for all the food types in each month in descending order. i.e. a rank of 1 means the food was the most preferred during that month. No data=*









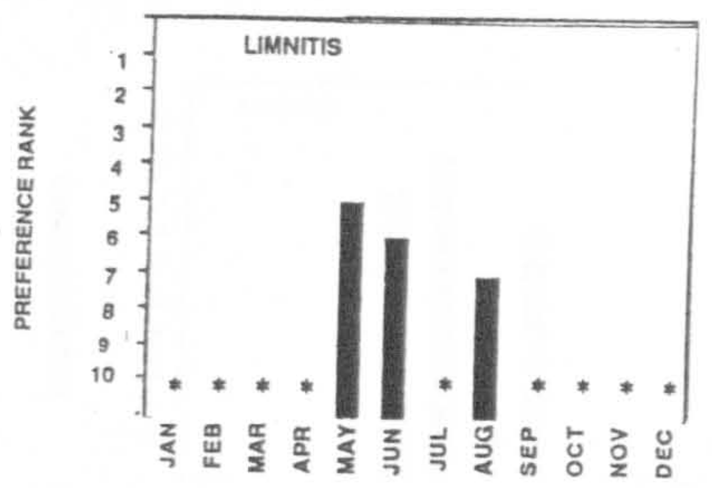
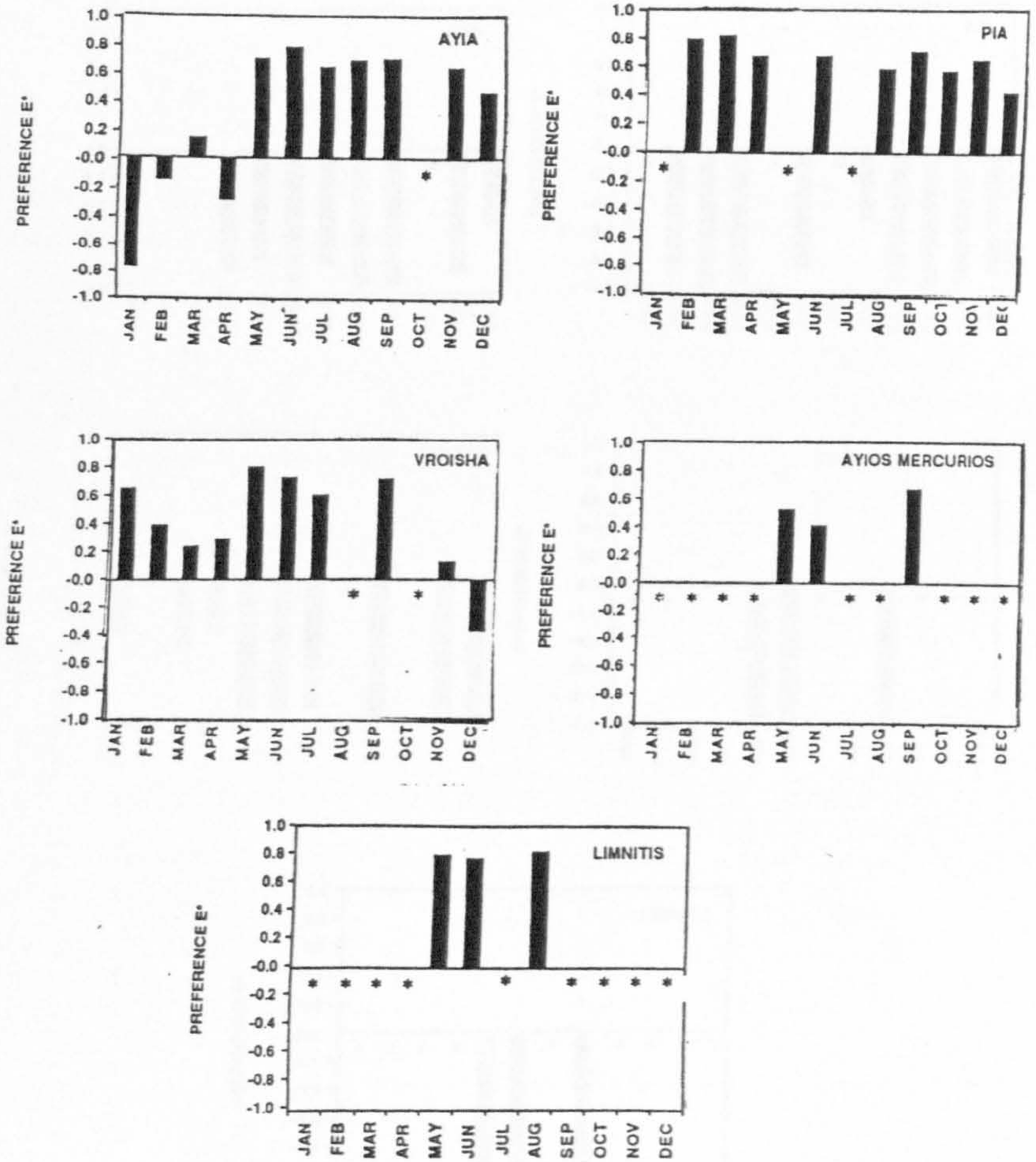


Fig 6.3

Preference index E* for non-graminaceous monocotyledons.

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS (AYIOS) AND LIMNITIS.
E*=[W-(1+N)] / [W+(1+N)] where N=no. of different kinds of food; W= r+p / sum of all r+p
r=percentage frequency of each food in the diet; p= percentage frequency of each food in the environment. No data=*.



RANK OF THE E* VALUES FOR NON-GRAMINACEOUS MONOCOTYLEDONS

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS (AYIOS) AND LIMNITIS.
Calculated by ranking the E* values for all the food types in each month in descending order. i.e. a rank of 1 means the food was the most preferred during that month. No data=*

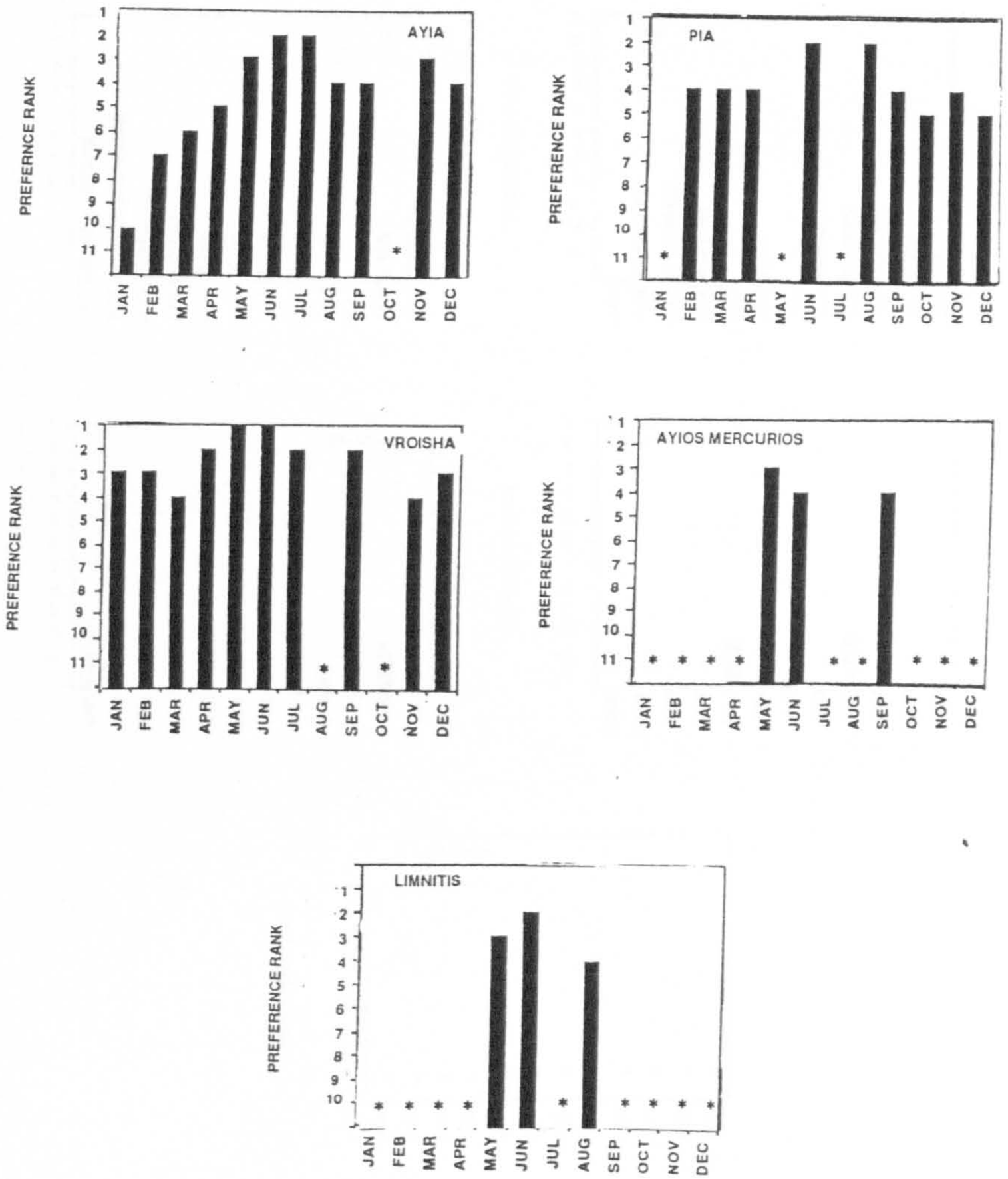


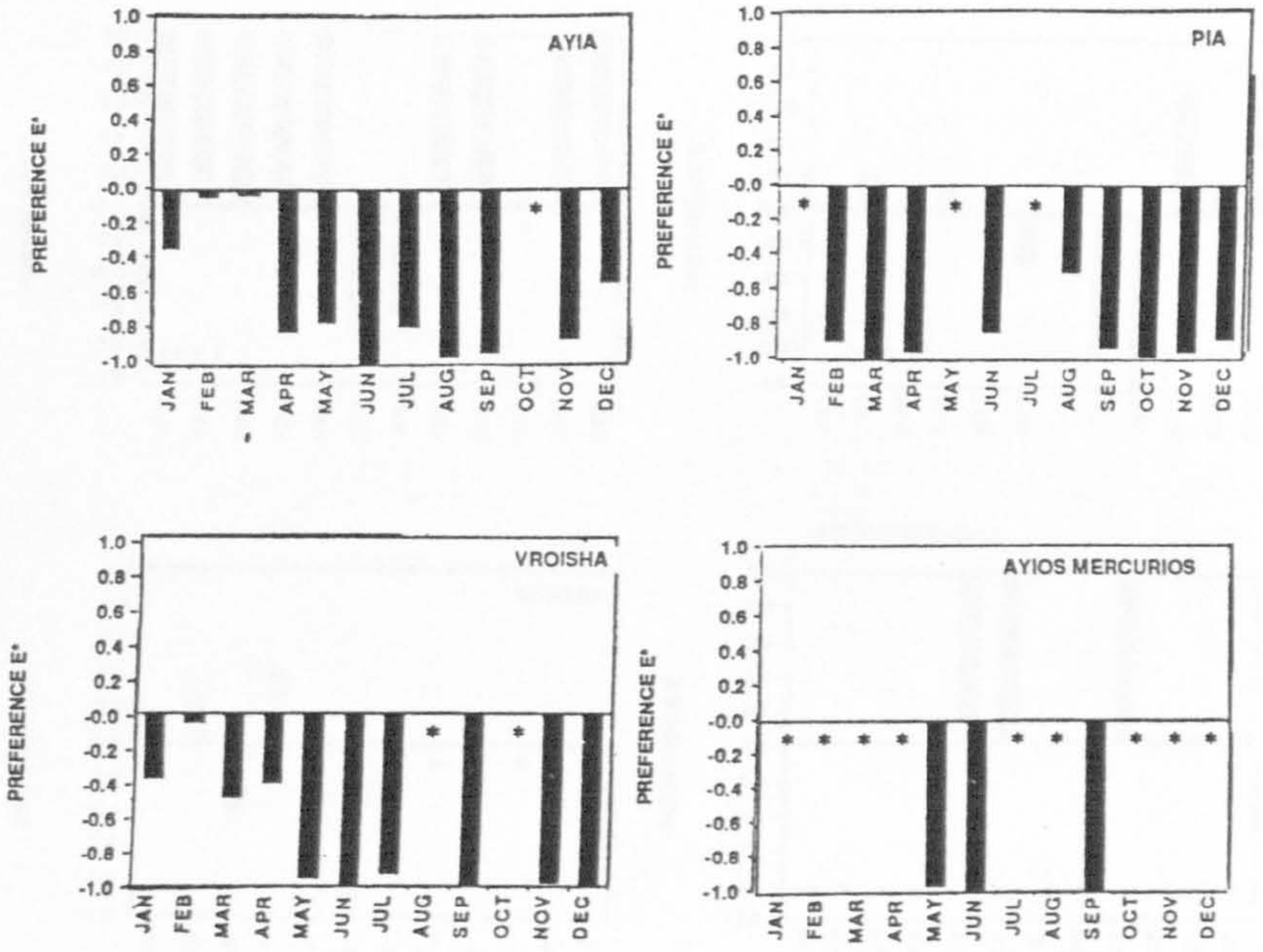
Fig 6.4

Preference index E* for *Cistus spp.*

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS (AYIOS) AND LIMNITIS.

$E^* = \frac{[W-(1+N)]}{[W+(1+N)]}$ where N=no. of different kinds of food; $W = \frac{r+p}{\text{sum of all } r+p}$;

r=percentage frequency of each food in the diet; p= percentage frequency of each food in the environment. No data=*.



RANK OF THE E* VALUES FOR *Cistus* spp.

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS (AYIOS) AND LIMNITIS.

Calculated by ranking the E* values for all the food types in each month in descending order. i.e. a rank of 1 means the food was the most preferred during that month. No data=*

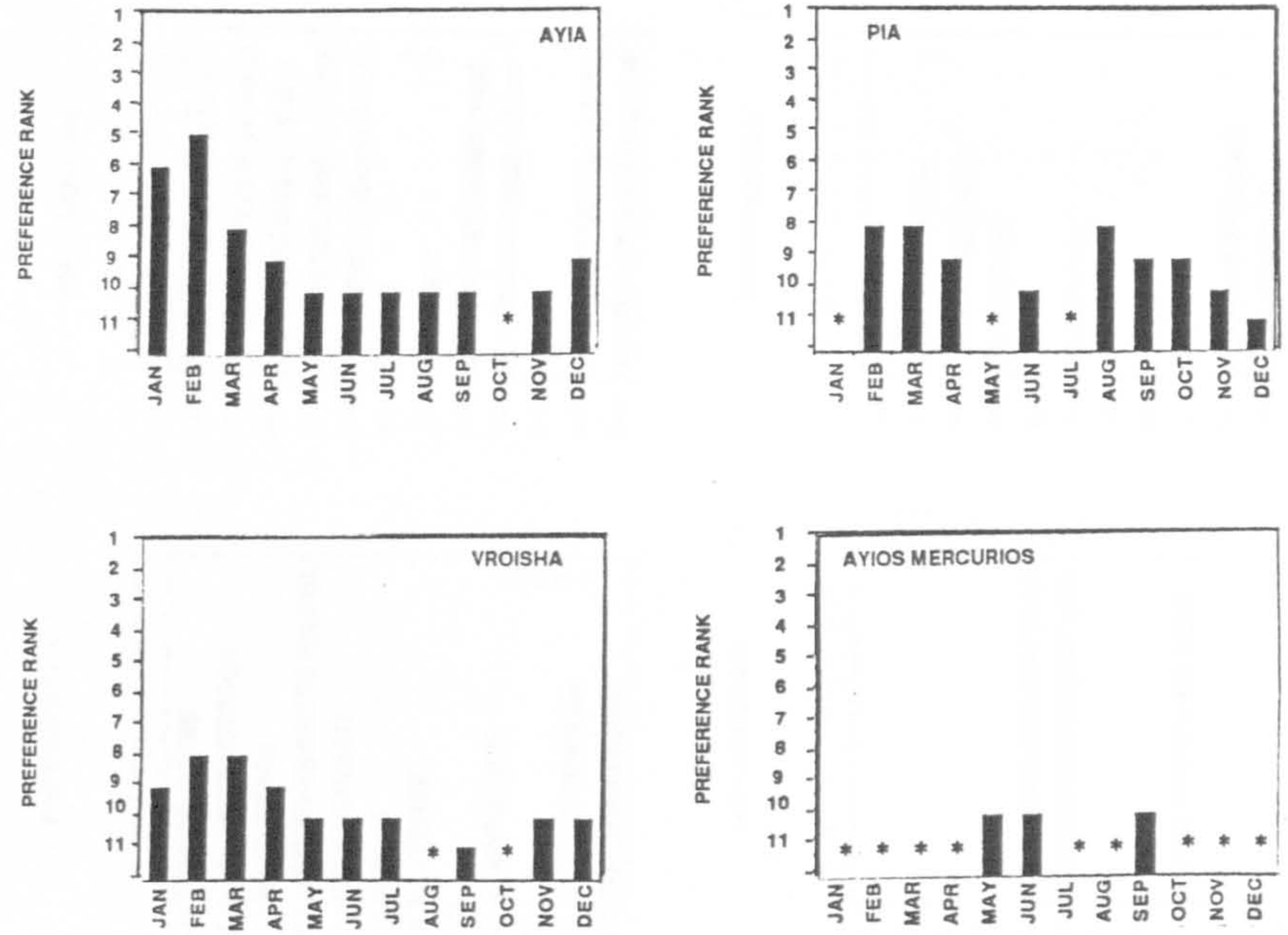


Fig 6.5

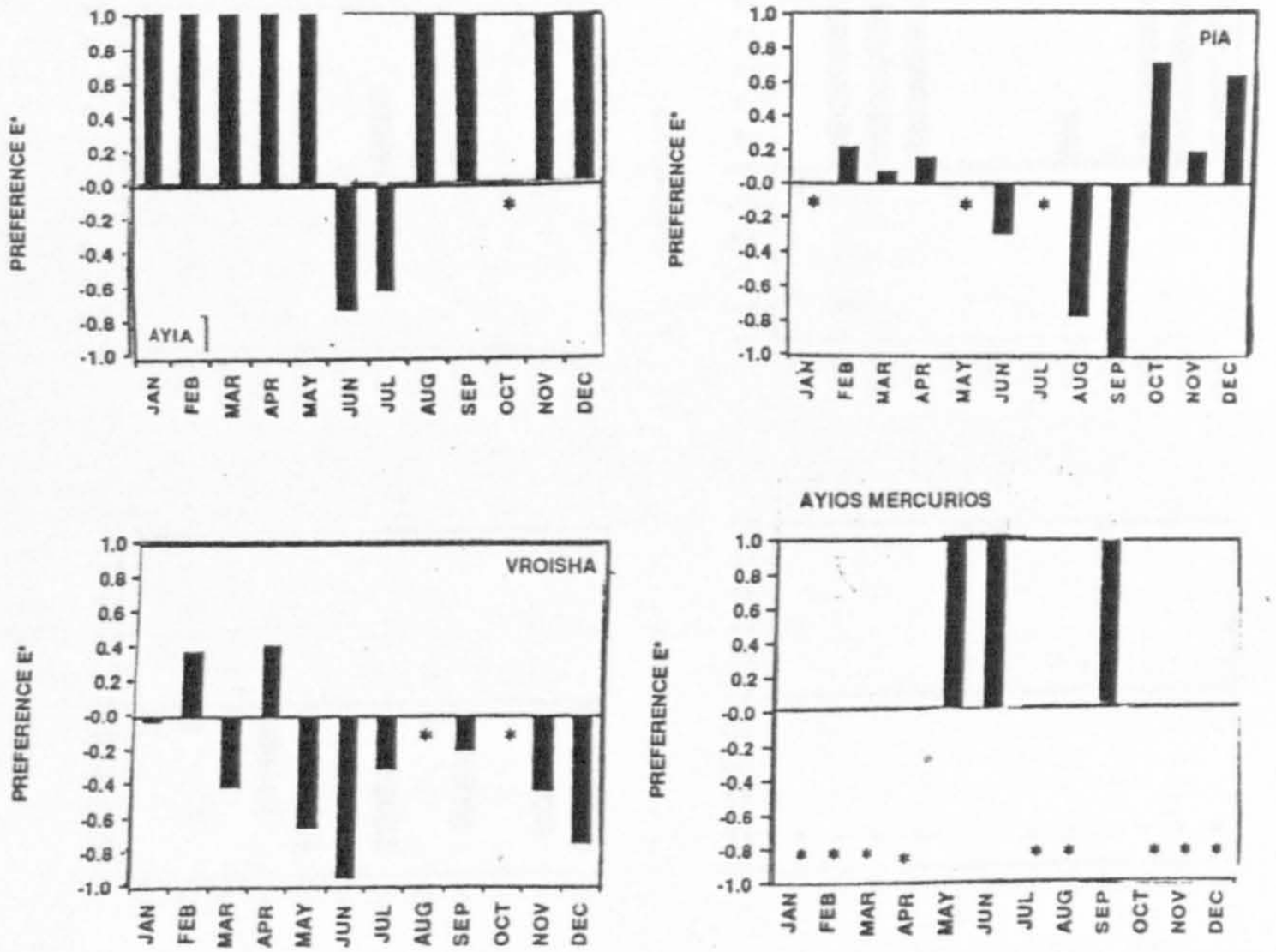
Preference index E* for *Lithodora hispidula.*

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS (AYIOS) AND LIMNITIS.

$E^* = \frac{[W-(1+N)]}{[W+(1+N)]}$ where N=no. of different kinds of food; $W = \frac{r+p}{\text{sum of all } r+p}$;

r=percentage frequency of each food in the diet; p= percentage frequency of each food in the environment. No data=*.

N=The food type was neither in the faeces nor in the environment.



RANK OF THE E* VALUES FOR *Lithodora hispidula.*

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS (AYIOS) AND LIMNITIS.

Calculated by ranking the E* values for all the food types in each month in descending order. i.e. a rank of 1 means the food was the most preferred during that month. No data=*

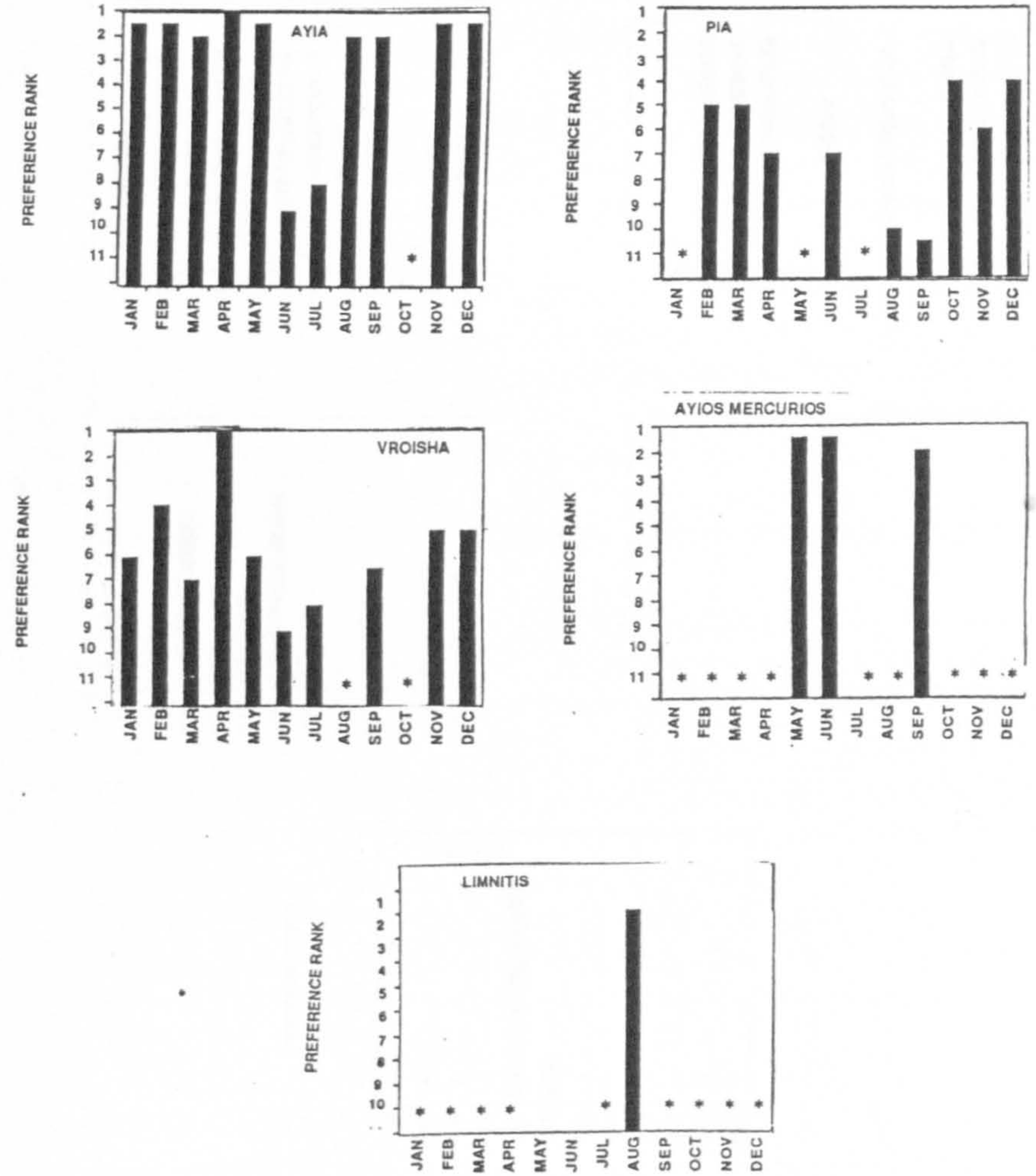


Fig 6.6

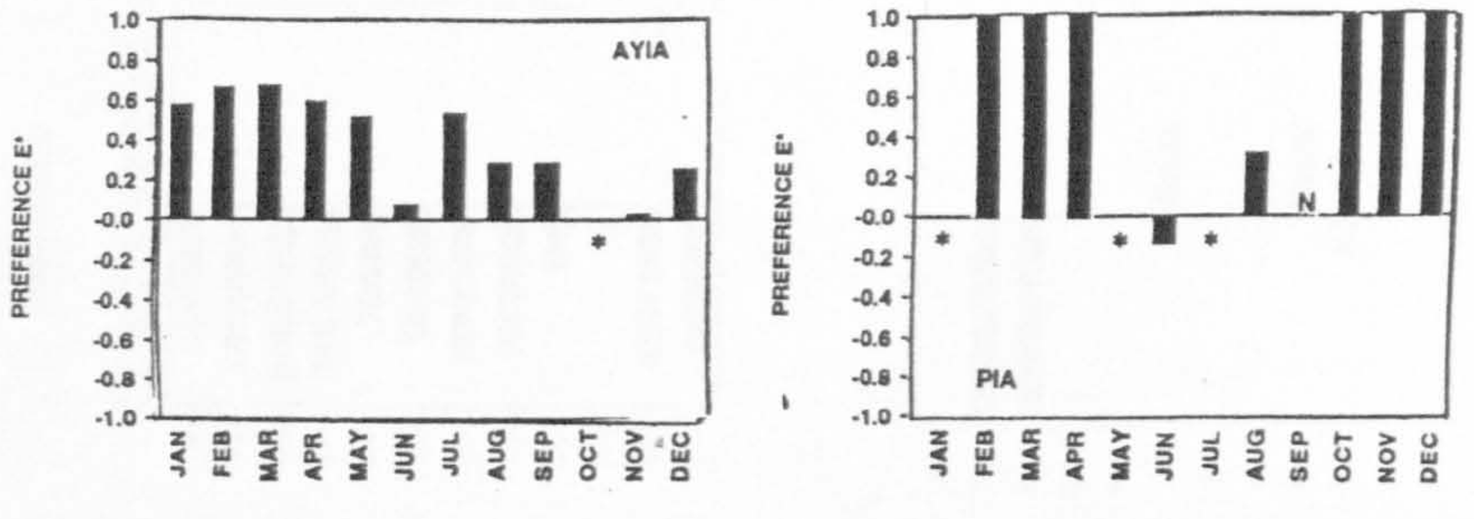
Preference index E* for *Teucrium kotschyanum.*

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS (AYIOS) AND LIMNITIS.

$E^* = \frac{[W-(1+N)]}{[W+(1+N)]}$ where N=no. of different kinds of food; $W = \frac{r+p}{\text{sum of all } r+p}$;

r=percentage frequency of each food in the diet; p= percentage frequency of each food in the environment. No data=*.

N=The food type was neither in the faeces nor in the environment.



RANK OF THE E* VALUES FOR *Teucrium kotschyanum.*

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS (AYIOS) AND LIMNITIS.

Calculated by ranking the E* values for all the food types in each month in descending order. i.e. a rank of 1 means the food was the most preferred during that month. No data=*

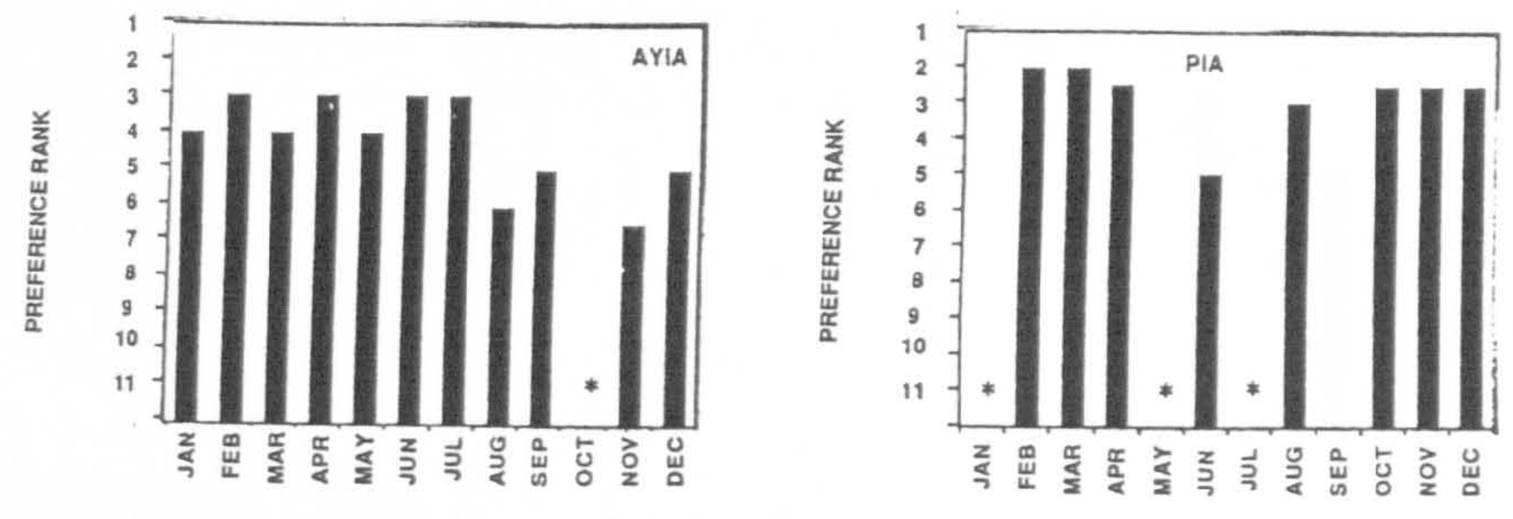


Fig 6.7

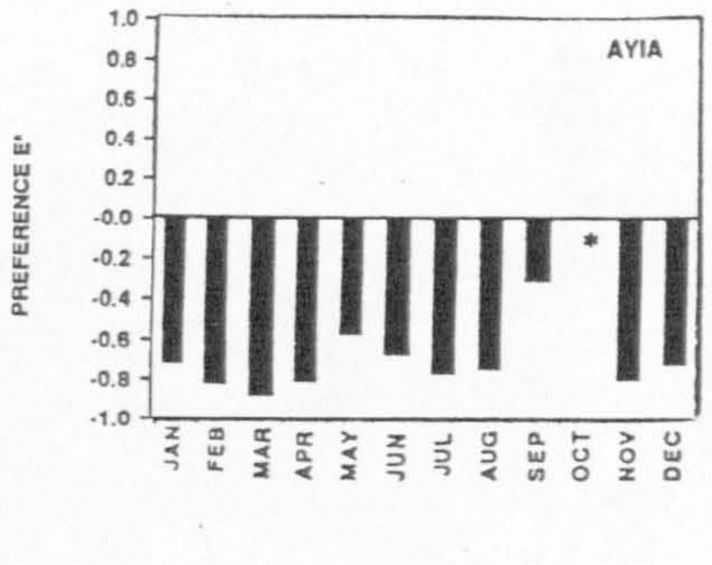
Preference index E* for broadleaved trees.

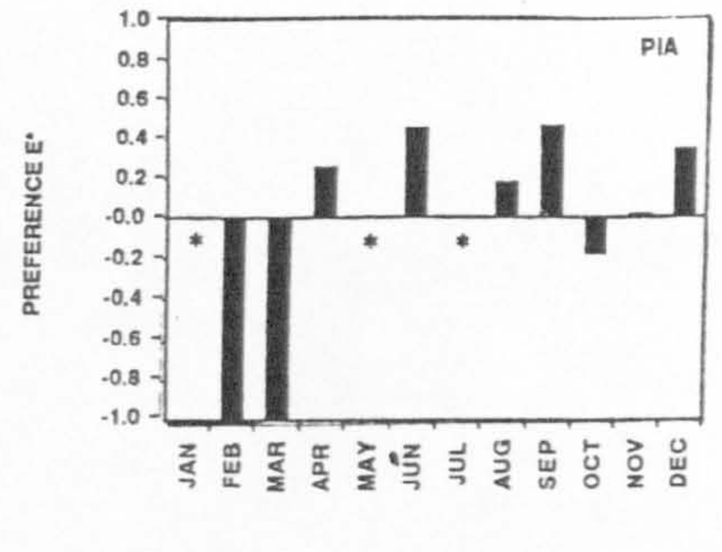
For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS (AYIOS) AND LIMNITIS.

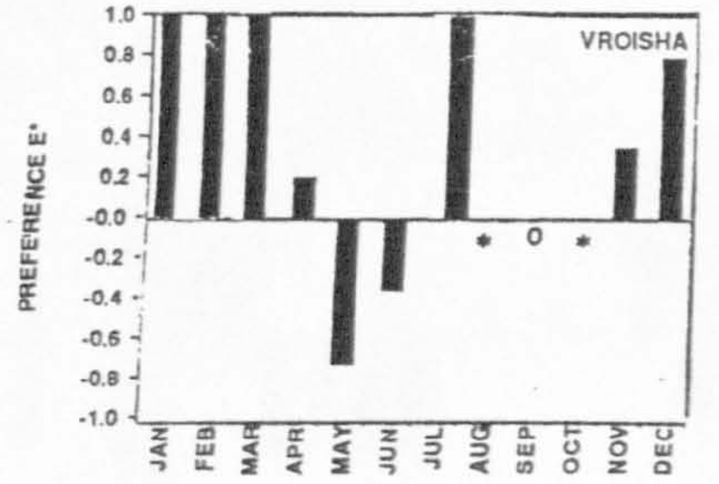
$E^* = \frac{[W-(1+N)]}{[W+(1+N)]}$ where N=no. of different kinds of food; $W = \frac{r+p}{\text{sum of all } r+p}$;

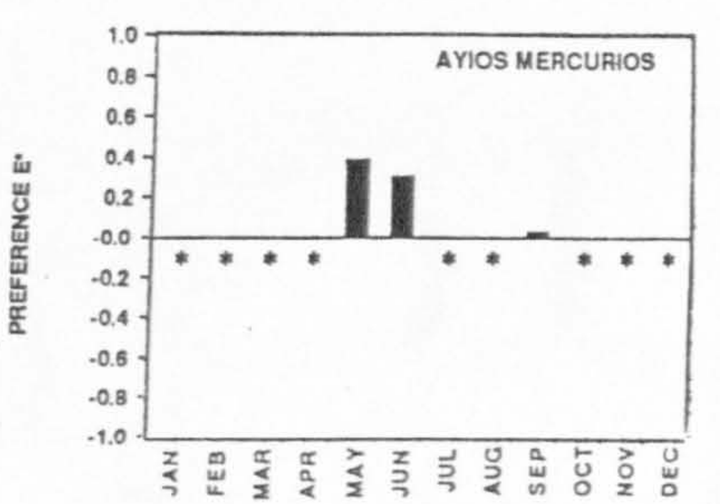
r=percentage frequency of each food in the diet; p= percentage frequency of each food in the environment. No data=*. 0=E* was equal to zero.

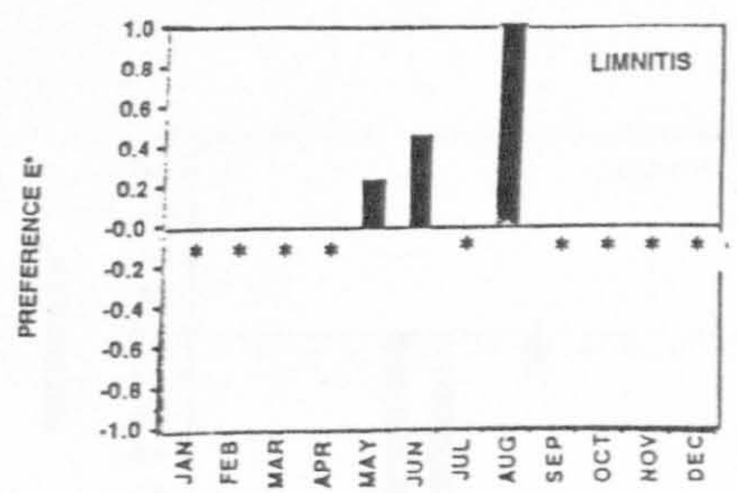
N=The food type was neither in the faeces nor in the environment.







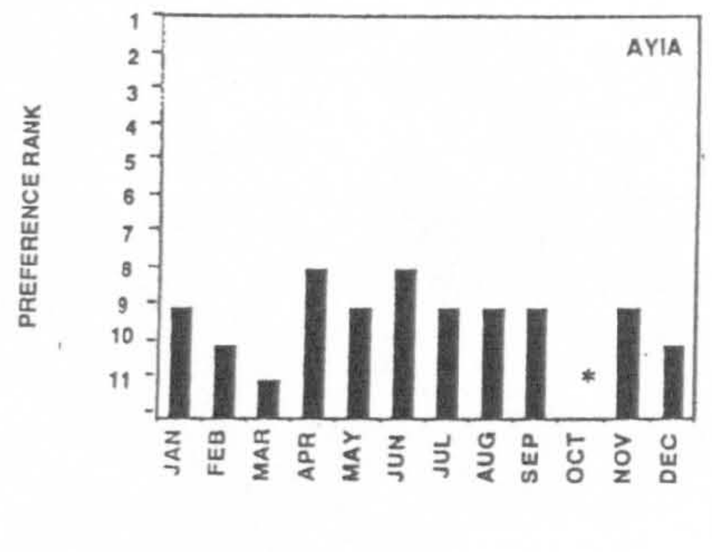


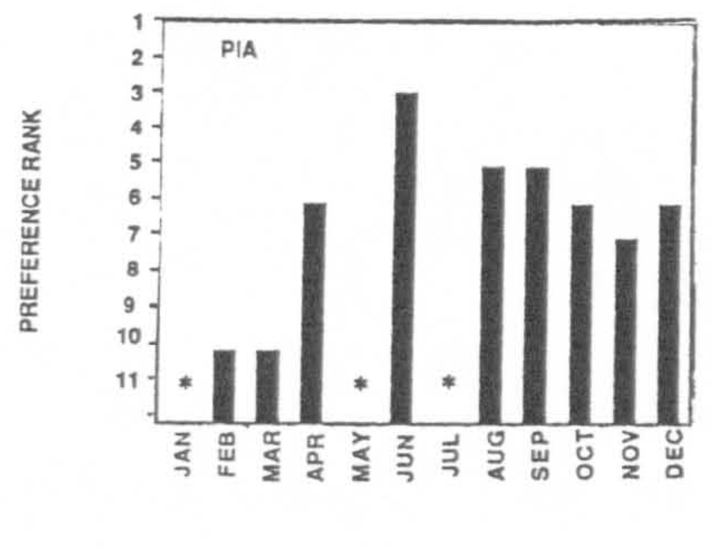


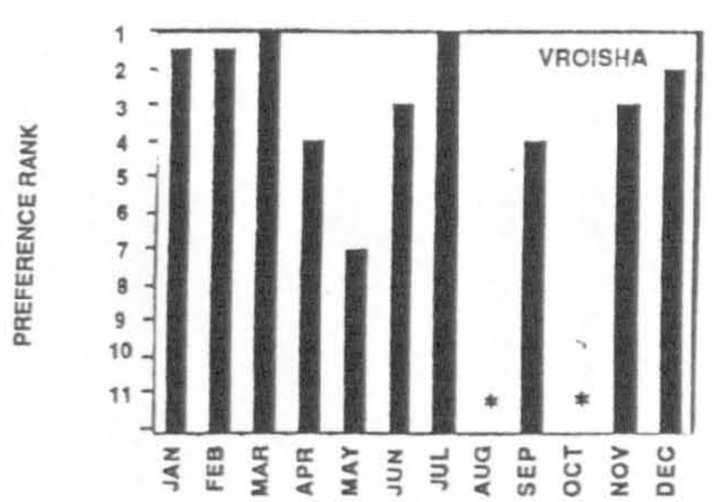
RANK OF THE E* VALUES FOR BROADLEAVED TREES.

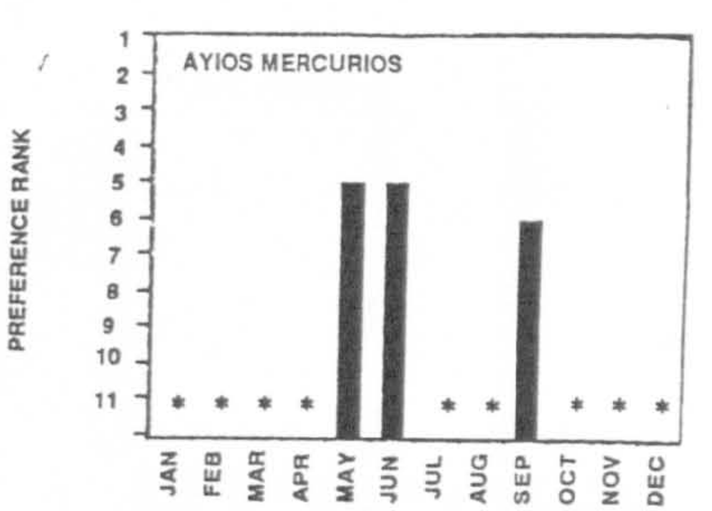
For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS (AYIOS) AND LIMNITIS.

Calculated by ranking the E* values for all the food types in each month in descending order. i.e. a rank of 1 means the food was the most preferred during that month. No data=*









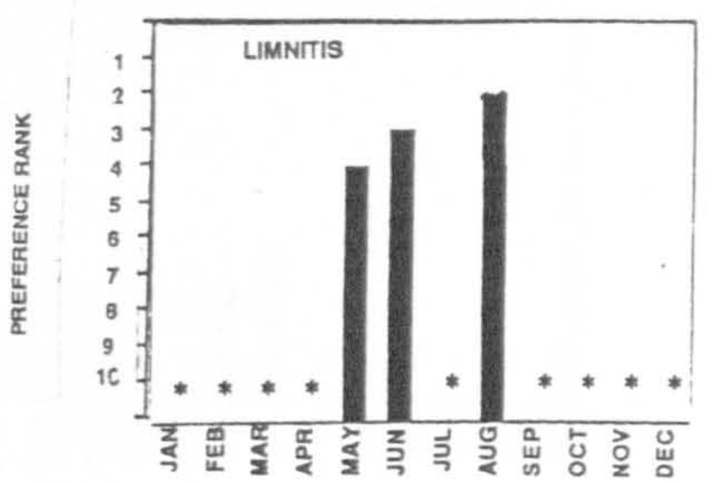


Fig 6.8

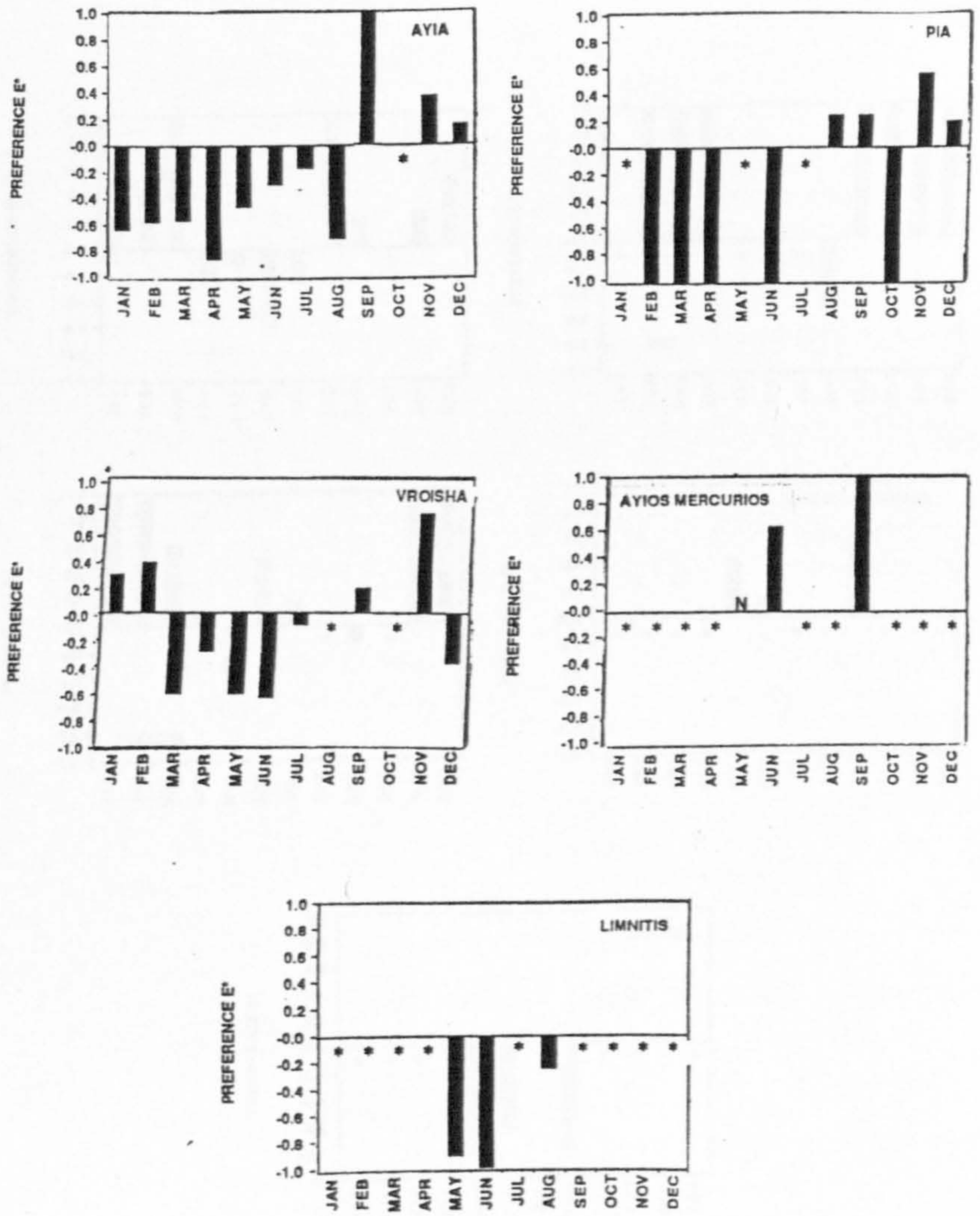
Preference index E* for *Asphodelus aestivus*.

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS (AYIOS) AND LIMNITIS.

$E^* = \frac{[W-(1+N)]}{[W+(1+N)]}$ where N=no. of different kinds of food; $W = \frac{r+p}{\text{sum of all } r+p}$;

r=percentage frequency of each food in the diet; p= percentage frequency of each food in the environment. No data=*.

N=The food type was neither in the faeces nor in the environment.



RANK OF THE E* VALUES FOR *Asphodelus aestivus*.

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS (AYIOS) AND LIMNITIS.

Calculated by ranking the E* values for all the food types in each month in descending order. i.e. a rank of 1 means the food was the most preferred during that month. No data=*

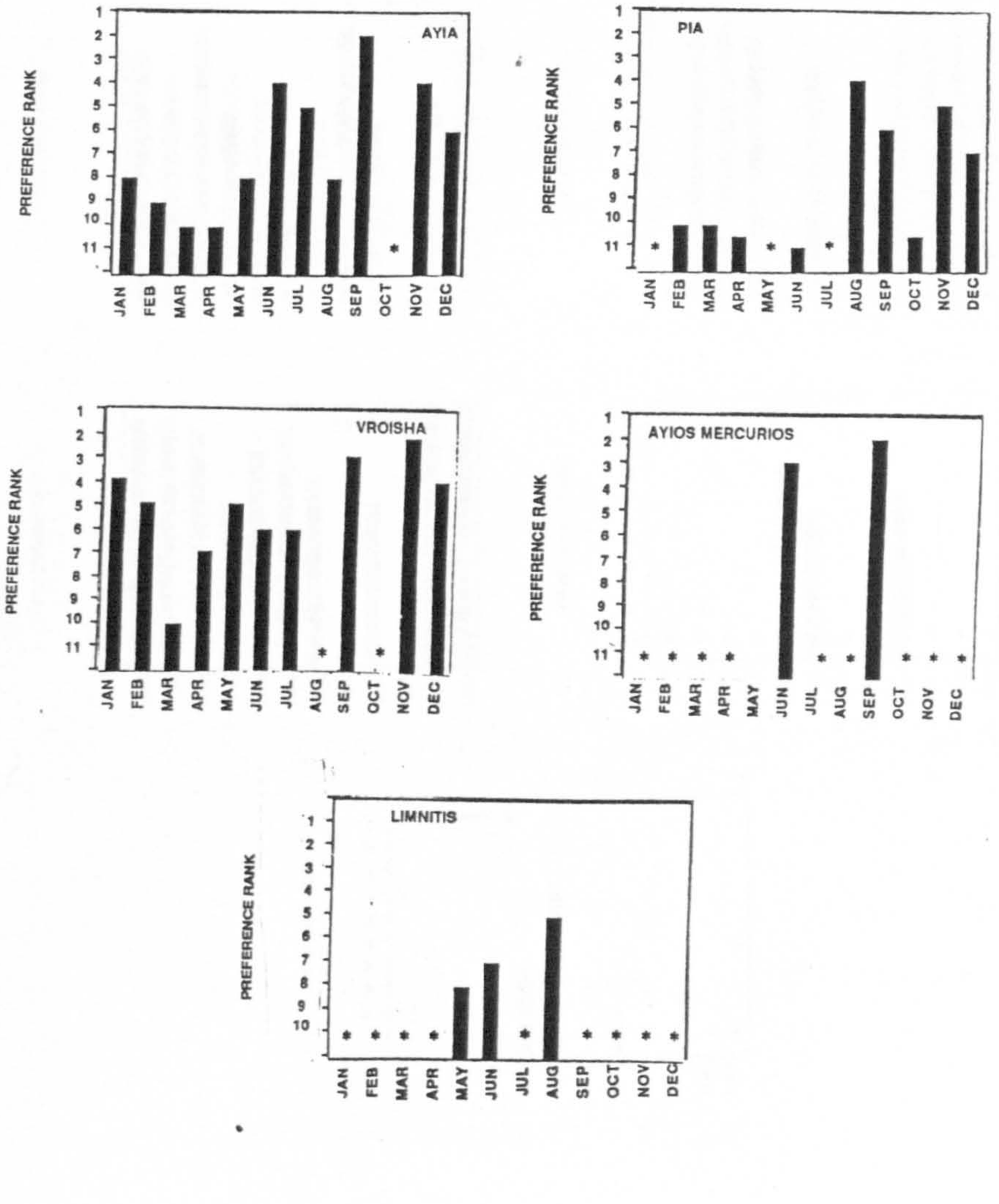


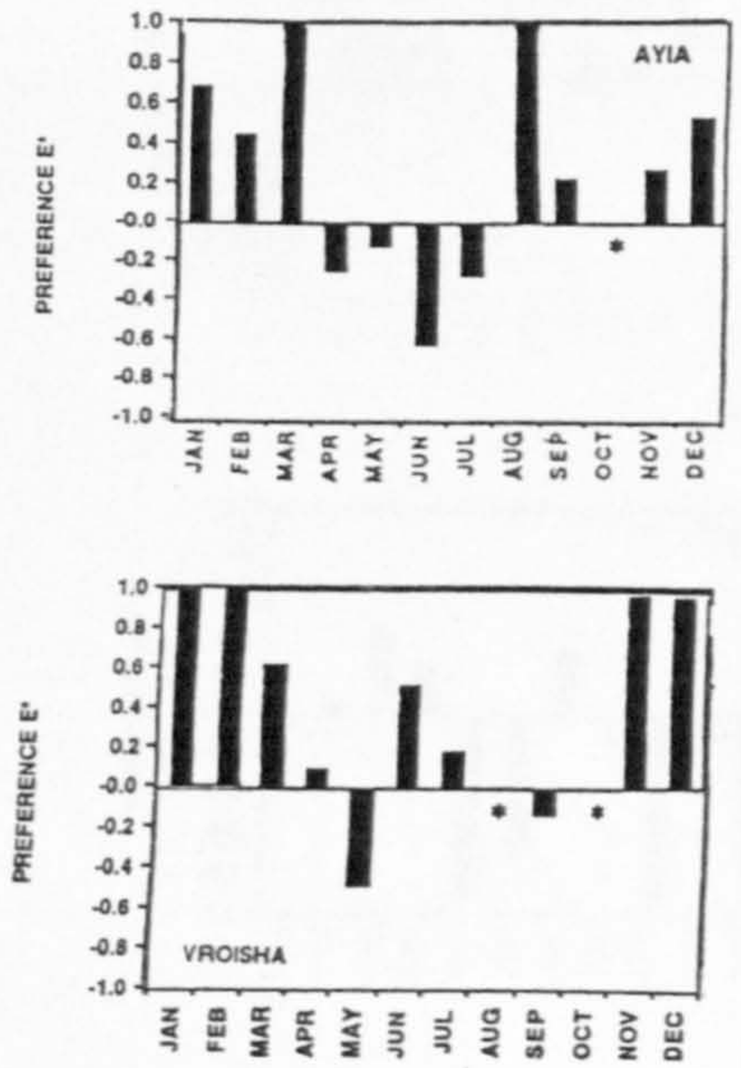
Fig 6.9

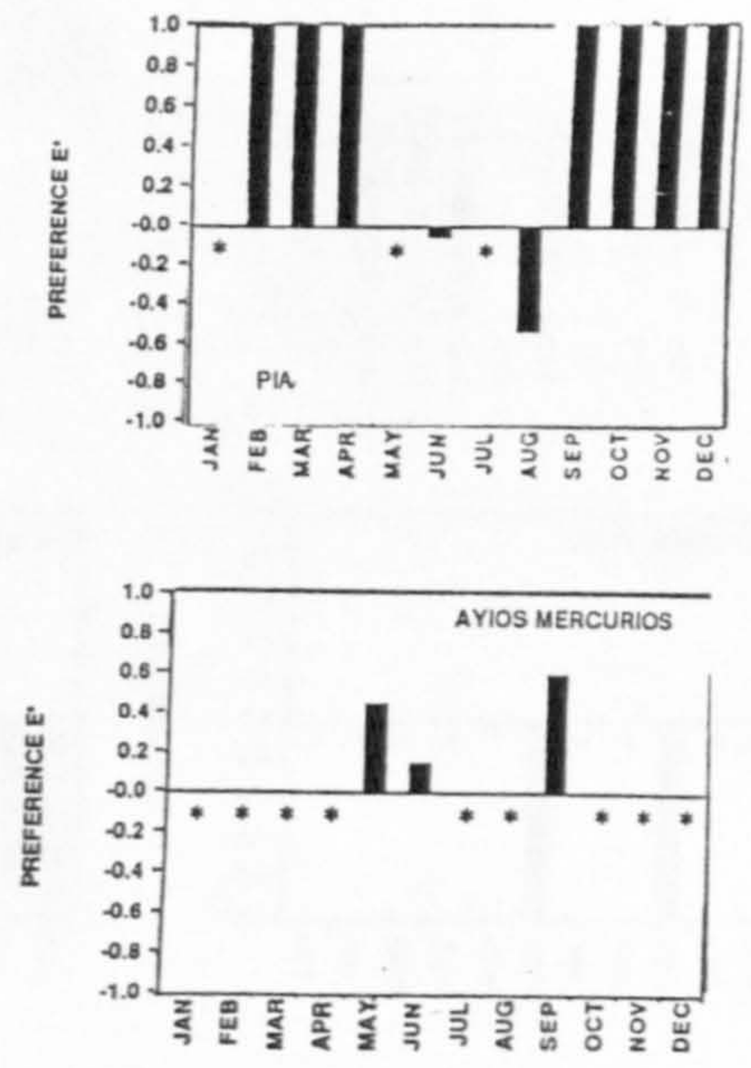
Preference index E* for *Pistacia terebinthus* and *Trifolium clypeatum.*

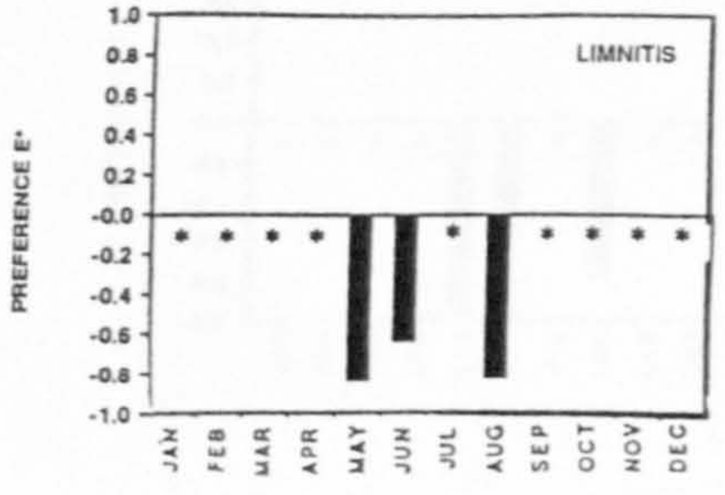
For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS (AYIOS) AND LIMNITIS.

$E^* = \frac{[W-(1+N)]}{[W+(1+N)]}$ where N=no. of different kinds of food; $W = \frac{r+p}{\text{sum of all } r+p}$;

r=percentage frequency of each food in the diet; p= percentage frequency of each food in the environment. No data=*.



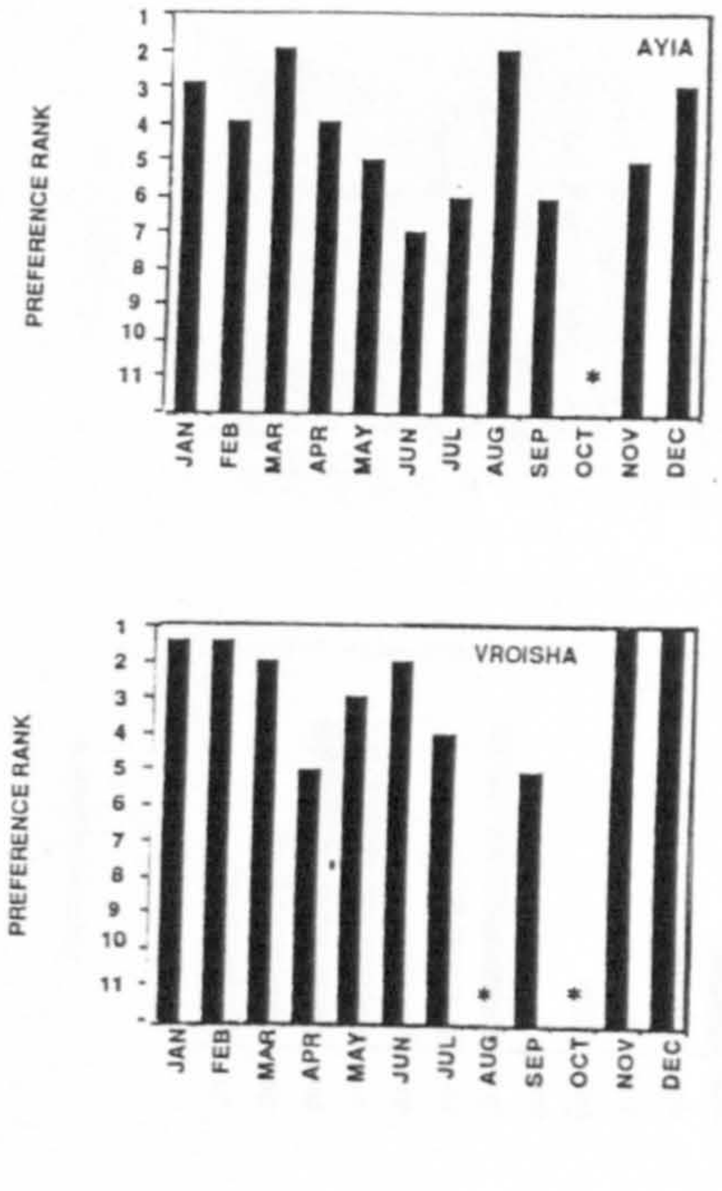


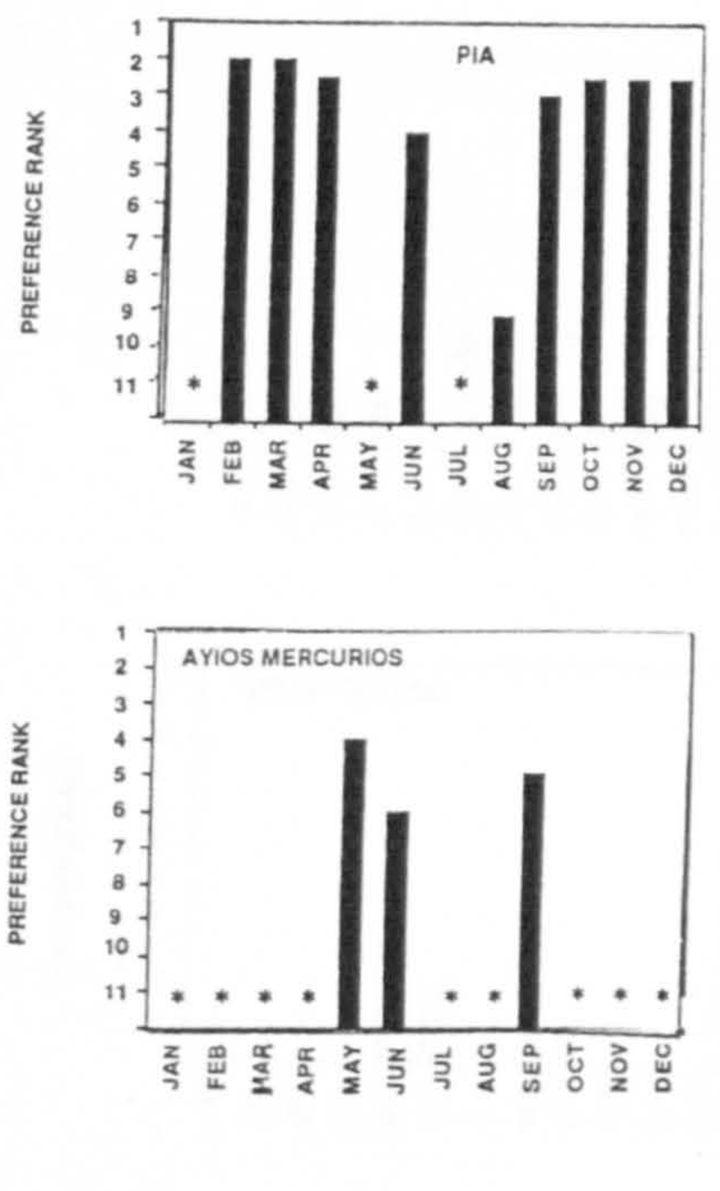


RANK OF THE E* VALUES FOR *Pistacia terebinthus* and *Trifolium clypeatum.*

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS (AYIOS) AND LIMNITIS.

Calculated by ranking the E* values for all the food types in each month in descending order. i.e. a rank of 1 means the food was the most preferred during that month. No data=*





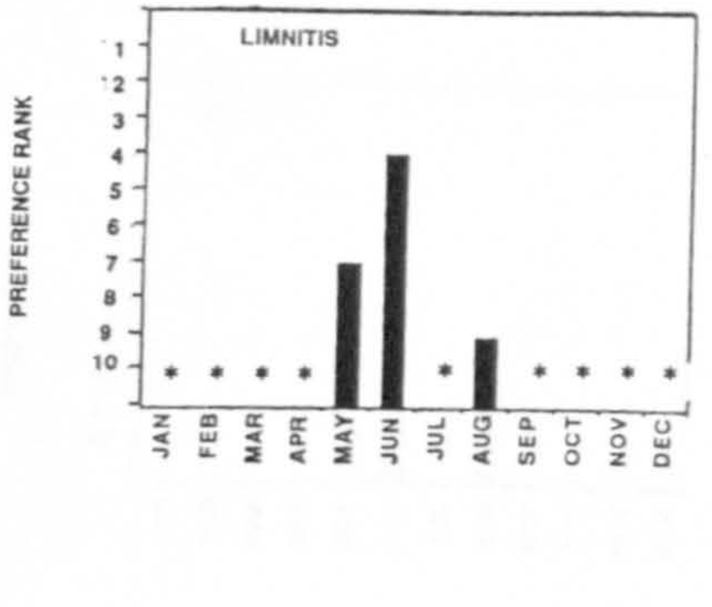
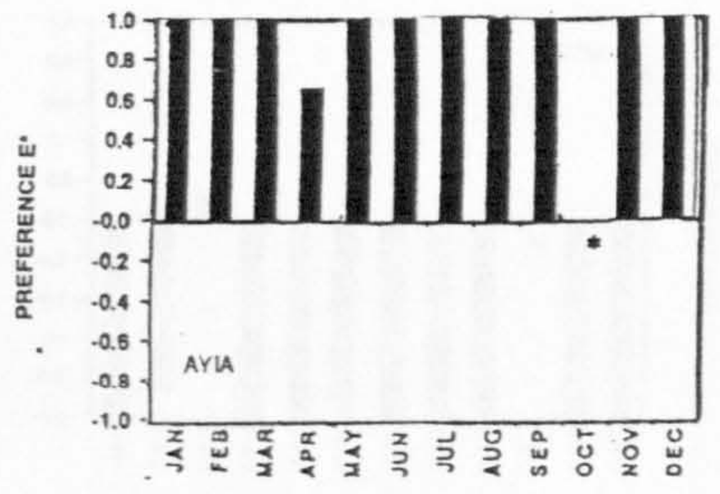
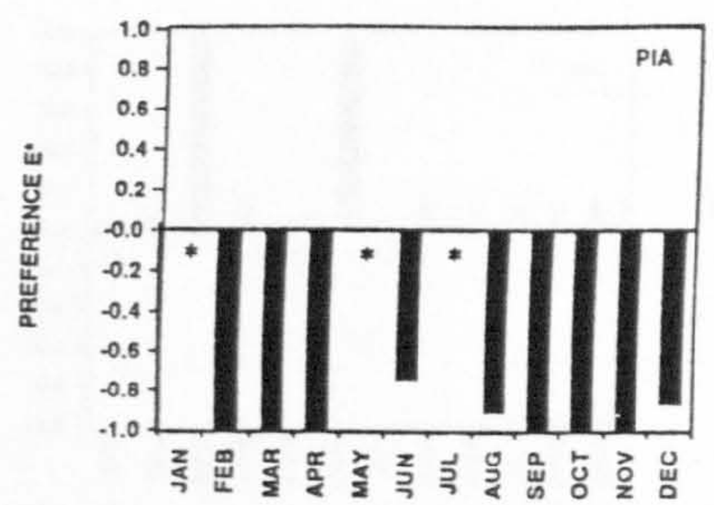


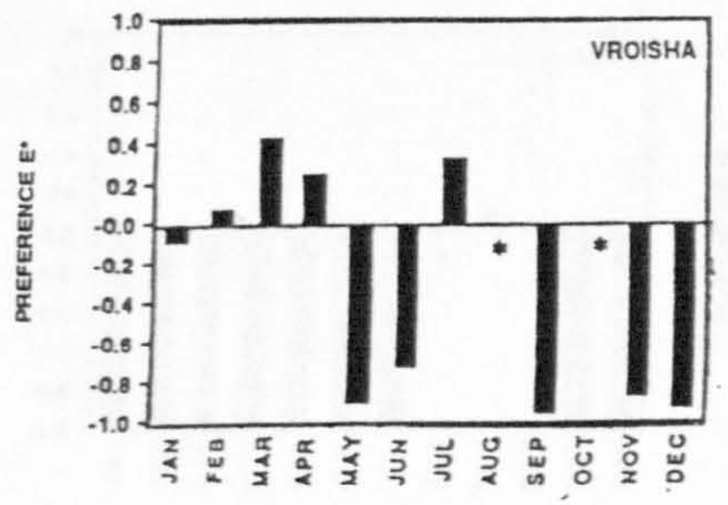
Fig 6.10

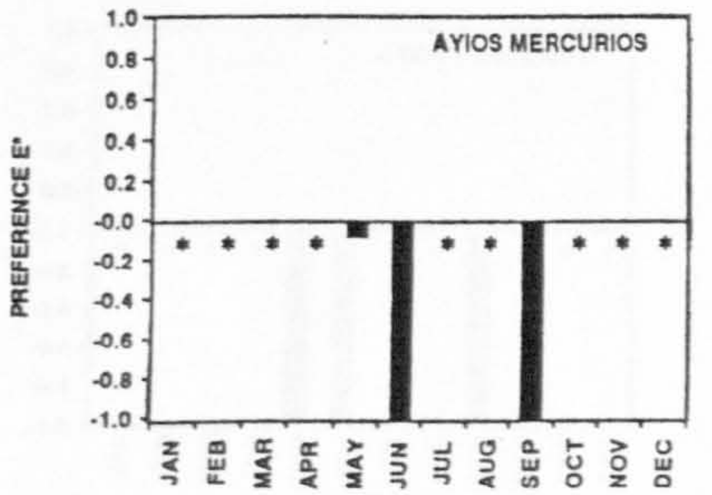
Preference index E* for *Pinus brutia*.

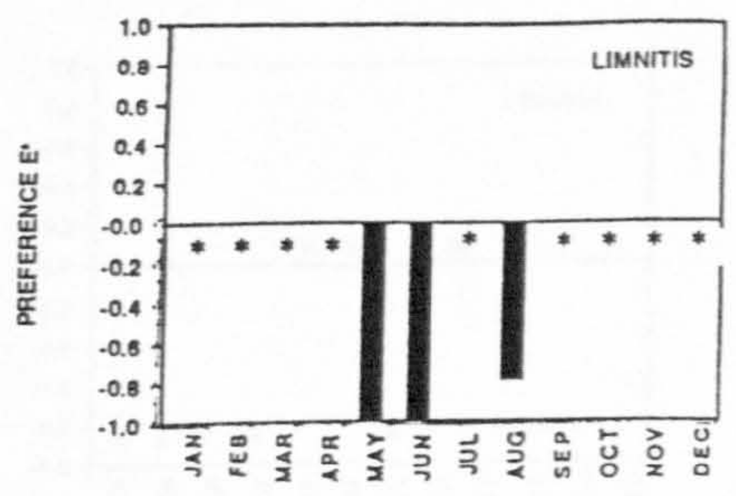
For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS (AYIOS) AND LIMNITIS.
$E^* = \frac{[W-(1+N)]}{[W+(1+N)]}$ where N=no. of different kinds of food; $W = \frac{r+p}{\text{sum of all } r+p}$;
r=percentage frequency of each food in the diet; p= percentage frequency of each food in the environment. No data=*.





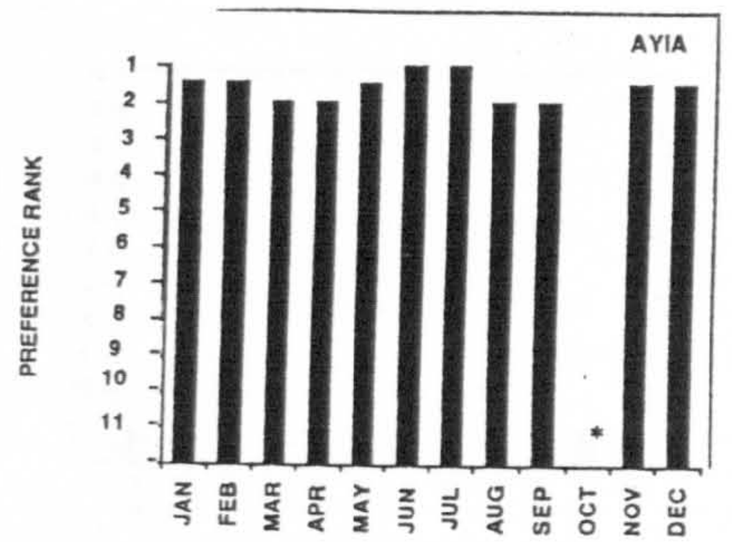


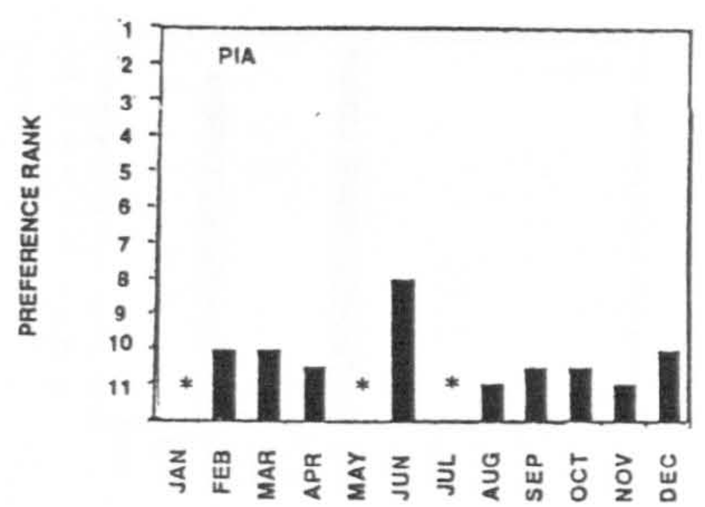


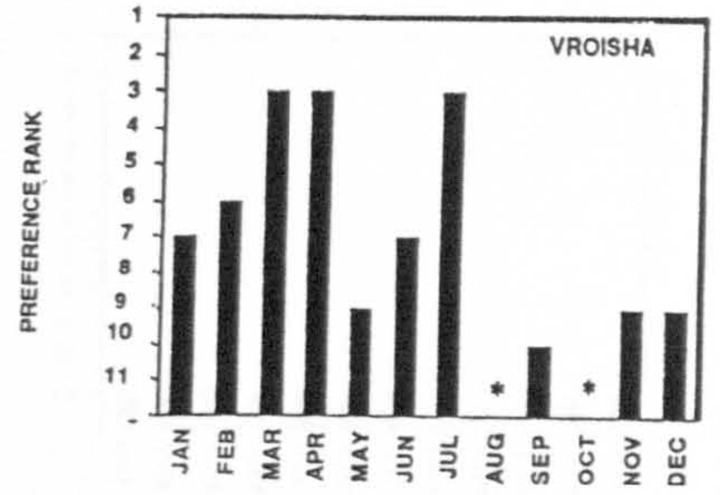


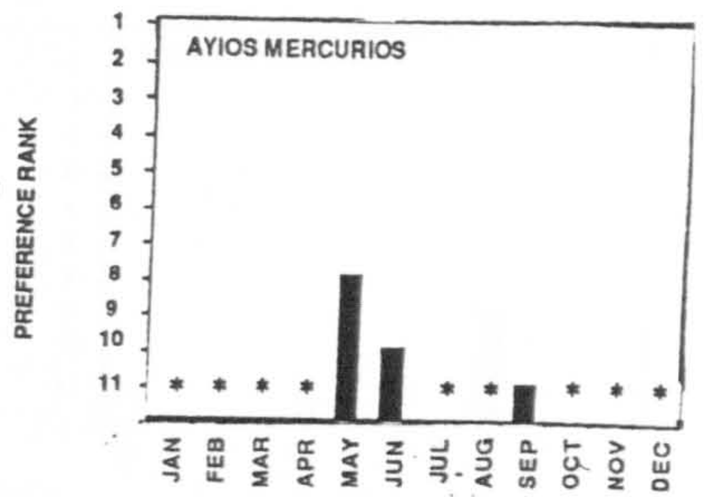
RANK OF THE E* VALUES FOR *Pinus brutia*.

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS (AYIOS) AND LIMNITIS.
Calculated by ranking the E* values for all the food types in each month in descending order. i.e. a rank of 1 means the food was the most preferred during that month. No data=*









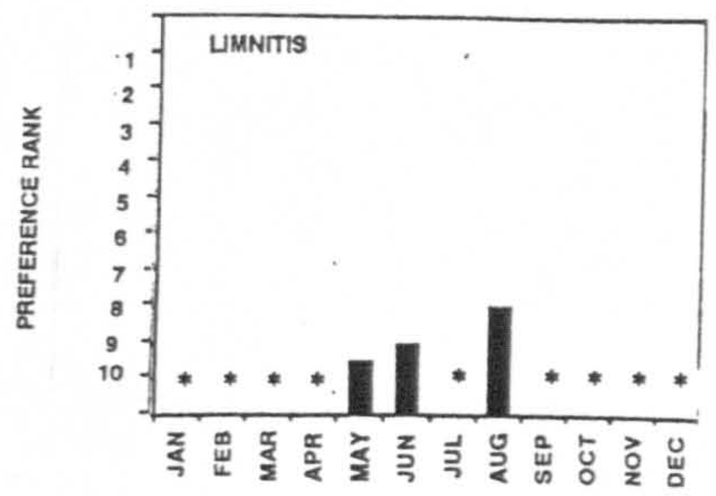


Fig 6.11

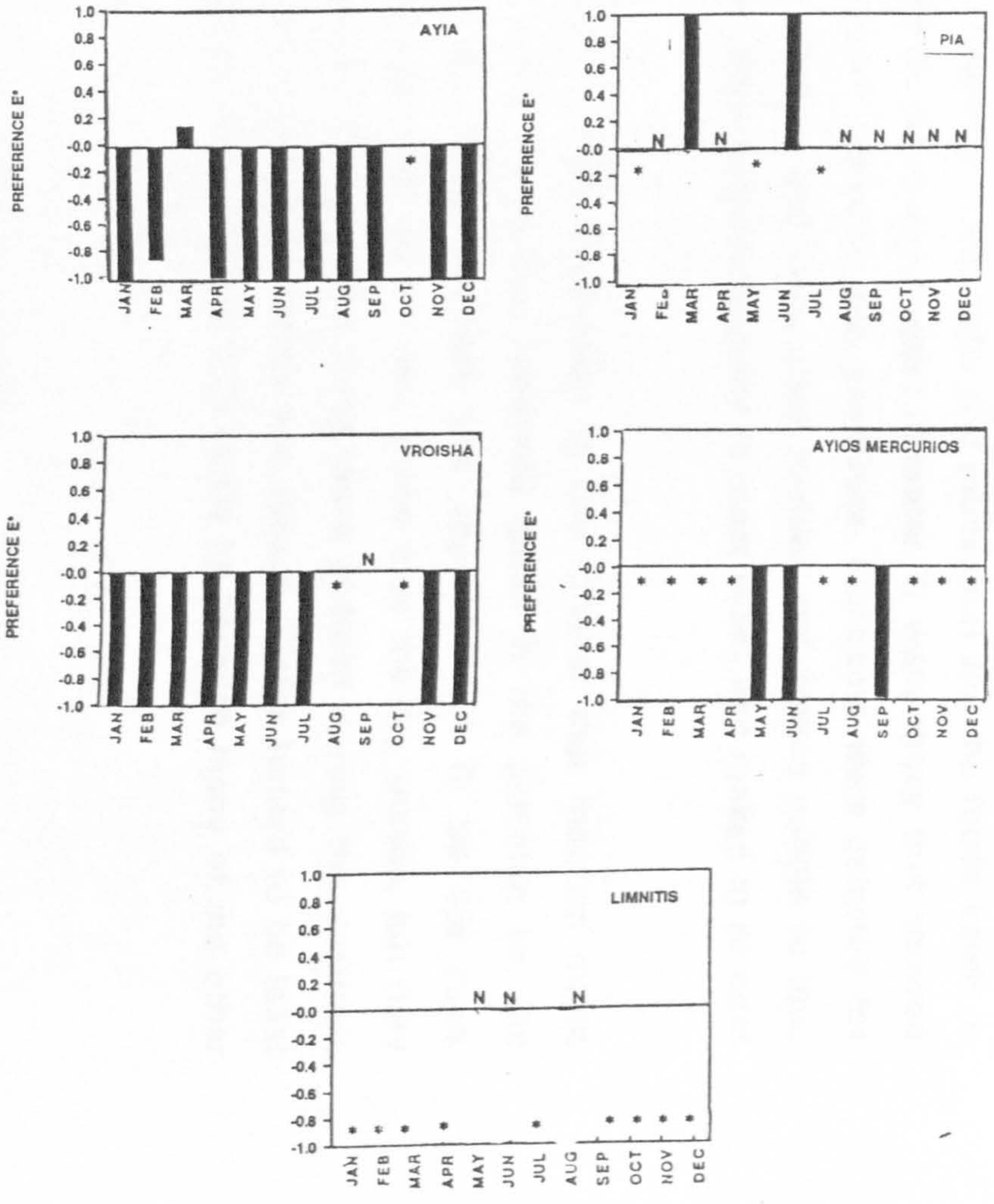
Preference index E* for *Rubus sanctus*.

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS (AYIOS) AND LIMNITIS.

E*=[W-(1+N)] / [W+(1+N)] where N=no. of different kinds of food; W= r+p / sum of all r+p

r=percentage frequency of each food in the diet; p= percentage frequency of each food in the environment. No data=*.

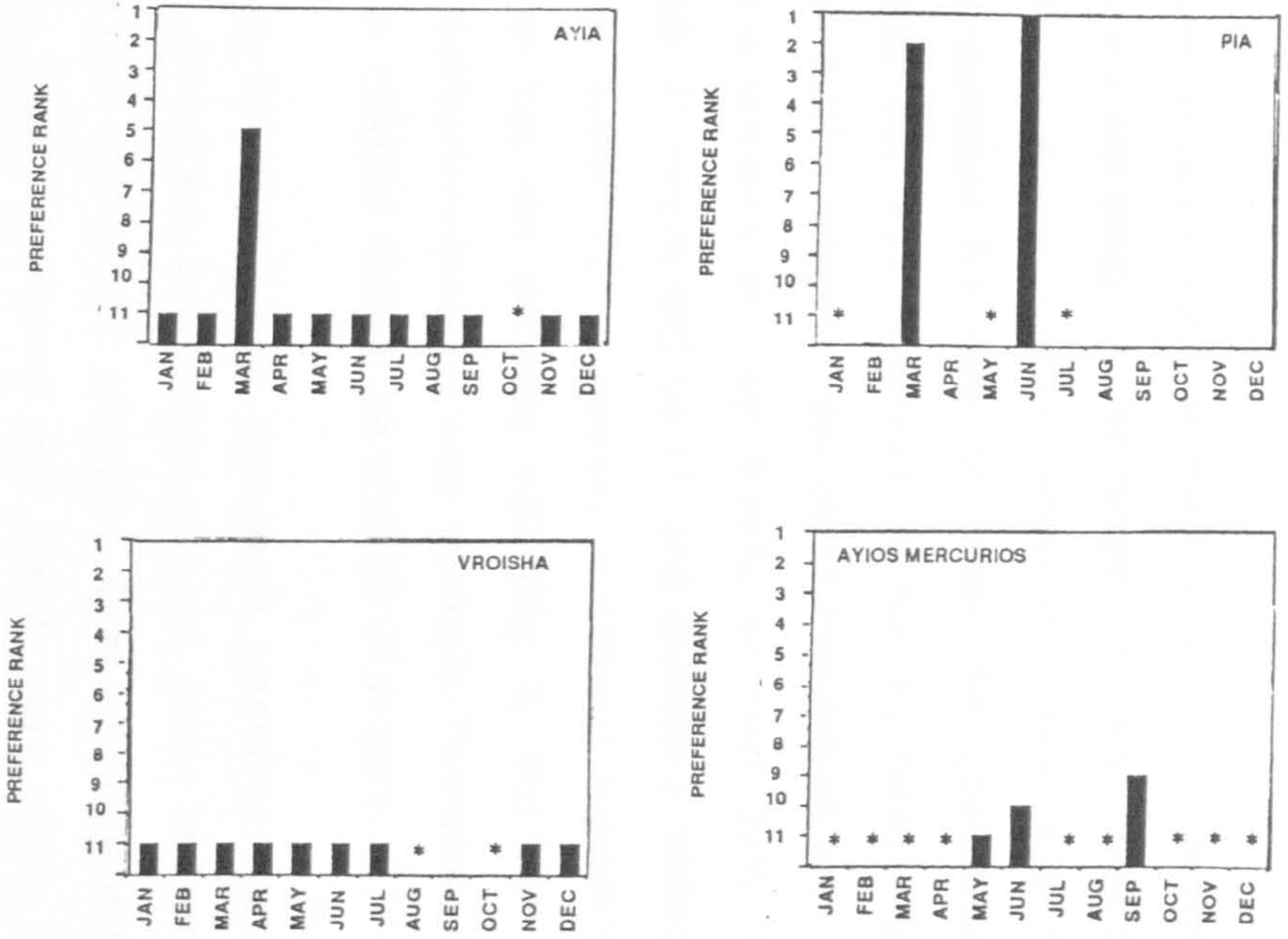
N=The food type was neither in the faeces nor in the environment.



RANK OF THE E* VALUES FOR *Rubus sanctus*.

For the valleys of AYIA, PIA, VROISHA, AYIOS MERCURIOS (AYIOS) AND LIMNITIS.

Calculated by ranking the E* values for all the food types in each month in descending order. i.e. a rank of 1 means the food was the most preferred during that month. No data=*



6.4 DISCUSSION

It is first important to point out that the use of any selectivity index seems to be misleading at the extremes of the range. This was well demonstrated in the results above in several instances, when the plant was not recorded as available in the environment (i.e rare, or when the quadratting method was perhaps inappropriate) but was recorded as having been ingested. In these instances, it did not matter whether the plant comprised less than 1% of the diet (e.g. *Teucrium* in Limnitis in May: 0.56%) or over 20% (e.g. *Teucrium* in Ayia in January: 23%), E* would still be +1, and therefore ranked highly. A small amount in the faeces could well represent accidental ingestion, or the animal 'testing' a rare food but not actually selecting it; but the E* value would indicate that it was being selected for very strongly. Therefore the E*=+1 values in the results for this chapter should be viewed with care.

It was shown in Chapter 4 that the most important components of the mouflons' diet throughout the year were grasses, forbs and non-graminaceous monocots, especially in spring and summer. Grasses were eaten slightly more in the wet season, other monocots and forbs were eaten more in the dry season. Broadleaved trees were of little importance in spring, although during summer, autumn and winter they comprised 15-20% of the diet. Shrubs were eaten most (33%) during the winter, least in summer (9%) and 18-21% in spring and autumn.

The three main foods (grasses, forbs and monocots) and the foods eaten in the smallest quantities (Pine and *Rubus*) (Chapter 4) were those that showed the clearest patterns of selection and avoidance. Monocots were selected for and ranked highly; grasses and forbs were avoided and ranked middle to low; and pine and *Rubus* were strongly avoided in most cases and ranked at or near bottom.

It was suggested in the introduction to this chapter that mouflon might simply select for those plants that remained green in the summer: i.e. the forbs, shrubs and the trees. However, this appeared not to be the case. Non-graminaceous monocots did not stay green over the dry season, but they were strongly selected for; whereas forbs were avoided during the summer, although not to such an extent as in the wet season. Forbs tended to be least strongly avoided in the late summer. This could be because many of the other

food categories were at their least digestible or least proteinaceous during the dry season (Chapter 3), whereas forbs remained above the minimum threshold for digestibility and crude protein all year. They would therefore have provided an available source of food whilst other foods became less nutritious.

The E* values for grasses differed from valley to valley (although generally indicating some degree of avoidance); but when the ranks were examined it appeared that they ranked higher in spring or in midsummer than at other times of the year. Ruminants select for grasses more when they are green and have a high leaf to stem ratio (Arnold and Dudzinski 1978). Grasses were at their greenest and most digestible in the winter and spring months in Cyprus, when rain fell frequently; grasses then matured and produced flowering heads at the end of spring, then dried up (Chapter 3). It is possible that in the late summer, the dried-up grasses were more difficult to find (or had already been eaten) than the non-grass monocots (such as Liliaceae, Iridaceae, Amaryllidacae) , which had broader, more obvious and fleshy leaves, which dried out less rapidly than grasses. This could be one reason for the dietary switch from grasses to monocots and forbs from the wet to the dry season. The E* values for monocots were mostly higher ranking in late summer than in winter, indicating more selection for these plants in the dry season. Perhaps this is because other foods started to appear again at the start of the winter rains, and mouflon could then select not only for monocots but for other plants as well. It seems that although forbs and grasses were major parts of the diet, they were not eaten according to their availability.

The shrub component of the Cyprus animals' diet deserves comment. During the summer months, *Cistus creticus*, the most common *Cistus* species (Chapter 2) in the forest, exuded a sticky, odorous substance from its leaves which may have been the cause of its avoidance by the animals. Although *Cistus* spp. were very common, and available all year round, they were always avoided. Mouflon were observed eating *C. creticus* in spring and in winter. *C. creticus* was more digestible than the non-odourous *C. salviifolius* (Appendix 3), so it is probable that the species found in the faeces was *C. creticus*.

Two other shrubs, *Teucrium kotschyanum* and *Lithodora hispidula*, although available all year, were only eaten at certain times. *T. kotschyanum* was eaten most in winter and in spring (up to 20% of the diet in Ayia for example), which

was when the plant put out new growth and flowers. As described in Chapter 3, *T. kotschyanum* was less digestible and had a lower moisture content in summer than in winter and spring. *L. hispidula* was eaten mostly in the autumn and winter (11–13%) but not so much in summer (4%). Both these species were assigned E* values of +1 in several cases, when the plant appeared in the diet but not in the environment. This is an example of the possible misleading effect of the E* index at the extremes of the scale.

Conifers are rarely eaten by other wild sheep: Dall sheep avoided conifers (Hoefs 1974), as did bighorn sheep in Montana (Tilton and Willard 1981). In Corsica, mouflon were not seen to eat pine trees (Pfeffer 1967). In the Cyprus study, *Pinus brutia* fragments rarely appeared in the faeces, and were, according to the E* index, avoided most of the time, except in Ayia, due to pine being under-recorded in the environment. As was mentioned in Chapter 4, Ayia valley was in fact heavily forested with mature pine trees, which were not small enough to appear in the quadrats. However, pine needles covered the ground, and could have been ingested accidentally. An animal was observed to eat pines on only one occasion, when it appeared that the flowers at the terminal end of a shoot were being chosen. However, in the absence of other winter foods, Czechoslovakian mouflon were reported to eat small amounts of *Abies alba, Pinus sylvestris,* and *Picea excelsa* in winter and in spring. *Larix decidua* was eaten in small quantities only in spring (Mottl 1960).

Broadleaved trees were often selected for, except in Ayia. They were eaten less in Ayia than in the other valleys, although more shrubs (*Lithodora, Teucrium* and *Cistus*) were eaten in Ayia.

Other wild sheep studied, like the Cyprus mouflon, seem to depend a great deal on grasses and forbs. The Punjab urial *Ovis orientalis punjabiensis*, an animal of about the same body weight as the Cyprus mouflon, was reported to be primarily a grass feeder that does not seasonally switch to browse (Schaller 1977). The much larger Marco Polo sheep *O. ammon poli* ate *Carex* spp. and such forbs as *Primula* and *Delphinium* (Schaller 1977). Bighorn sheep also appear to eat mainly grasses (Shank 1982), or grasses and forbs (Shackleton 1985, Stelfox 1976); although in winter they have been reported to eat more shrubs than in summer (Blood 1967, Keating et al. 1983, Oldemayer et al. 1971, Schallenberger 1965, Tilton and Willard 1981). One exception is the study of Rominger et al. (1988) who found bighorns ate mostly browse in a habitat

which had very little grass available. Dall sheep also eat mainly grasses and forbs (Hoefs 1974). Feral Soay sheep ate grasses, especially in the spring, and ate *Calluna vulgaris* and grasses in the winter (Milner and Gwynne 1974). Domestic sheep, for which there is a considerable body of literature, are primarily grazers when there is good quality grass available (Alexander et al. 1983, Arnold and Dudzinski 1978, Bullock 1985, Squires 1980, Welch 1981) but will change their diet with pasture deterioration to other plants especially shrubs (Bullock 1985, Squires 1980, Westoby 1974, Wilson et al. 1975) or, in Australia, to flat-leaved chenopods (Ellis et al. 1977).

Sheep can be selective at some seasons and not at others: In winter, neither bighorns nor Soay sheep were selective (Keating et al. 1983, Milner and Gwynne 1974). However, both domestic and Soay sheep can be selective in summer when there is abundant forage available: (Milner and Gwynne 1974, Ellis et al. 1977, Grant et al. 1985). If Cyprus mouflon were less selective in the time of poor forage (summer and autumn) their E* values should have been closer to zero at this time than during the winter and spring, when there was a greater abundance and higher quality of forage. This was the case in Vroisha for forbs, *Asphodelus* and *Pistacia/Trifolium*, in Ayia for grasses and *Pistacia/Trifolium*, and in Pia for forbs. In Keating's et al. (1983) study of bighorns, it was suggested that the animals had the opportunity to be selective because the winter was unusually mild, with a large quantity of good quality forage available; but they fed nonselectively on what was available to them.

Therefore it seems that mouflon, although living in a forest habitat, follow the pattern of many other sheep in that they are primarily grazers on forbs and grasses, that they ingest grasses more when these are younger and greener, and that they will eat shrubs and, to some extent, broadleaved trees if necessary. They showed a slight shift in the degree of selectivity in some valleys for grasses and forbs, between the seasons of poor and good forage quality.

6.5 SUMMARY.

1. An electivity score was calculated for each food type by month and by valley. The foods for each month and valley were then ranked in order of preference. Monocots were highly preferred as a food all year, especially in the summer months, and ranked between 1 and 4th out of eleven food types.

2. Although they were quantitatively a major part of the diet, the forbs and grasses were eaten in lower proportions to those in which they occurred in the environment, and ranked between 5th and 9th.
3. *Cistus* was avoided all year, in all valleys, and ranked 8–11th.
4. *Lithodora hispidula* was generally avoided except where E*=+1 (Ayia, Ayios Mercurios, and Limnitis). This plant was not a major part of the diet in Ayios Mercurios or in Limnitis.
5. *Teucrium kotschyanum* was selected for in Ayia, avoided in Vroisha, and E*=+1 in the other three valleys.
6. Broadleaved trees were often selected for, except in Ayia.
7. *Asphodelus aestivus* was sometimes selected during the autumn and winter.
8. *Trifolium clypeatum* and *Pistacia terebinthus* were not eaten in Vroisha or Limnitis, but were selected for everywhere else.
9. *Pinus brutia* was avoided and was usually a low ranking food, except for Ayia valley, due to E*=+1. This in turn was due to pine trees not appearing in the quadrats in that valley.
10. *Rubus sanctus* was the least preferred plant of all the food types identified and the lowest ranking.
11. The diets of other wild sheep and of domestic sheep are also compared with that of mouflon, and the degree of selectivity exhibited by them with regard to season examined. Cyprus mouflon are slightly less selective for forbs, grasses and for two minor food types (*Pistacia/Trifolium* and *Asphodelus*) during the dry season than during the winter.

CHAPTER 7
GROUPING BEHAVIOUR

7.1 INTRODUCTION

There is now a considerable body of work on the reasons for animals living in groups. There are thought to be two main reasons for animals living in groups. These are: (a) predator detection and avoidance; and (b) to take the best advantage of food resources (Barnard 1983, Krebs & Davies 1987, Rubenstein 1978). The seasonal variation in the group sizes of Cyprus mouflon was investigated to see if it could be connected with the pattern of food resources. The seasonal composition of the groups was also examined, and the overall sizes, in comparison with those of other wild sheep.

PREDATION.

The predator detection strategy means that more eyes, ears, noses or other sense organs are present in a group than in a single individual. An individual in a group has a smaller chance of being taken by surprise by a predator than if it was alone (Krebs & Davies 1987). Each animal in a group can spend less time scanning for predators and more in other activities such as feeding, for example curlews *Numenius arquata* (Abramson 1979); Spanish ibex *Capra pyrenaica* (Alados 1985a); ostriches *Struthio camelus* (Bertram 1980); Bighorn sheep (Berger 1978, Risenhoover & Bailey 1985); pronghorn antelope (Berger et al 1983, Lipetz & Bekoff 1982); starlings *Sturnus vulgaris* (Powell 1974); (Pulliam 1973); African antelopes (Underwood 1982). Stacey (1986) found that smaller groups of yellow baboons *Papio cynacephalus* were more likely to rest near the relative safety of trees. Added to this is that as group size increases there is a reduced probability of an individual falling victim to a predator: the 'dilution' effect of groups. (Hamilton 1971, Bertram 1978, Vine 1971, 1973). This has been seen for monarch butterflies *Danaius plexippus* (Calvert et. al. 1979) horses *Equus caballus* (Duncan and Vigne 1979) and water skaters *Halobates robustus* (Foster & Treherne 1981).

The larger a group is, the more obvious it may become to a potential predator. Andersson & Wicklund (1978) found that the benefit of group mobbing of predators by a colony of fieldfares *Turdus pilaris* outweighed the

cost of conspicuousness. The optimum group size should combine a high level of predator detection (many eyes see more) with an acceptable degree of conspicuousness. However, observed group size is often larger than the optimum (Pulliam & Caraco 1984) because single individuals would benefit by joining these groups and thus swell them above the optimal size (Sibly 1978).

Until 1940, mouflon in Cyprus suffered heavy predation from man, who often hunted with dogs. On the nearby mainland areas of Asia Minor from which it is assumed the mouflon came, large mammal predators such as wolves still exist. Therefore both in ancient times and in recent years there has been strong selection pressure for antipredator strategies. Feral goats *Capra hircus* living in Scotland still show increased overall vigilance and decreased time spent scanning for predators per individual as group size increases (Maisels 1982), even though there has been little or no predation in the last hundred years.

FORAGING

Species feeding on large ephemeral clumps of food (coarse grained resources) often live in groups (Crook 1964, Jarman 1974, Crook & Gartlan 1966.) Group living may enhance the success of finding food if the food resource is patchily distributed. Locally abundant resources have been defined as patchy; resources that are evenly distributed but in small quantities are referred to as non patchy (Krebs & Davies 1987). Amongst African ungulates Jarman (1974) found that forest dwelling species tended to be in small, often territorial groups, and to feed on highly nutritious, scattered food items, that were available throughout the year. Animals living in open country tended to be in larger groups and fed on grasses which were abundant but less nutritious, and were seasonal: i.e. only available for a short time.

Grouping can even vary within a species: Chamois *Rupicapra rupicapra* were found in larger groups in winter than in spring by Von Elsner-Schack (1985) and she explained this by food distribution differences; in winter food was found in few patches, and big groups concentrated on these. In spring and autumn resources were in many small scattered feeding areas, and the animals were therefore also in small scattered groups.

The effect of living in forest has been noted to reduce group size in some ungulate species (Eisenberg 1966, Estes 1974). For instance, Spanish ibex were

in larger groups in open habitats than in woods (Alados 1985b); the same occurred in *Oryx beisa* (Walther 1978) and chamois (Von Elsner-Schack 1985), and white-tailed deer (Geist 1974). This is thought to be due to the difficulty of maintaining a cohesive large group in a closed habitat because of the visual disruption (Ewer 1968, Walther 1978, Alados 1985b, Von Elsner-Schack 1985, Shackleton & Shank 1984).

Because of the Mediterranean climate in Cyprus (Fig 1.3), the hot dry summers cause the ground layer vegetation to dry up in the dry season (Chapter 3). In the Paphos forest in Cyprus, the ground layer vegetation was abundant in clearings only during the wet season and for a short while afterwards; i.e. from December to May. During the dry season when the ground layer dried up, only shrubs were still green and nutritious. Shrubs were fairly evenly dispersed throughout the forest, but the quantity and quality of available non-woody forage was smaller per unit area than that of forbs and grasses during the rainy season (Chapters 2 and 3).

Therefore mouflon in Cyprus might be expected to form large groups in winter concentrating on the lush forage in the clearings, and to be in smaller groups in summer, feeding on the more evenly dispersed but sparser food items. It was proposed to observe group size throughout the year to see if group sizes did in fact change according to season, and if this could be attributed to changes in the availability of food resources. It was also hoped that the overall group size patterns of the animals could be compared to those of other species of wild ungulates living both in forest and in open country to see if mouflon were indeed in smaller groups than would be expected if they were living in open country. Finally, it was hoped to investigate age/sex differences between mouflon grouping behaviour and possible differences in vulnerability to predation.

7.2 METHODS

The sex composition and sizes of all groups were recorded whenever animals were seen. Age can be estimated up to the first 4 years by growth rings on the horns and by the length of the horns. In Corsica, most male mouflon started mating from the age of 4.5 years, and it was rare for males

less than 3.5 years to succeed in mating (Pfeffer 1967). Other Asian wild sheep are similar: in the Pamir Marco Polo sheep start to mate from 3 years (Meklenburtzev 1948); as was the case for argali in Turkmenistan (Tzalkin 1948); Tian-Shan (Rumyantzev et al. 1935); and in Kazakhstan (Antipin 1941). Punjab urial females treated males of 3.5 years or less as subordinates (Schaller 1977). Because differences in behaviour would be expected between sexually mature and immature males, males were assigned to two classes in this study: old males (4 years old or more-and therefore sexually mature) and young males (3 years old or less-sexually immature.)

Cyprus mouflon females could not aged, but they were assigned to 'females with young' or 'females without young'.

The number of individuals in each group size was the unit of analysis. This made sense from the individuals' point of view. Suppose, of a sample of twenty groups, ten were single animals and ten were groups of ten animals. A hundred individuals chose to associate in large groups, and only ten individuals were alone. If the unit of analysis was frequency of groups in each group size class, equal weight would be given to the ten single animals as to the hundred in groups of ten. Thus, though single animals were in the minority, they would be over-represented. If the number of animals in each group were compared, the emphasis would be on the fact that there were many more animals in large groups than alone.

Chi-squared was used for all tests except where $N<20$ or where a 2x2 contingency table contained one or more cells with an expected frequency of less than 5, or, when $df>1$, if more than 20% of the cells in the table were less than 5. In these cases, where there was a 2x2 contingency table, the Fisher's test was used (Siegel 1956). If $df>1$, group size categories had to be combined in these cases until either chi-squared was possible, or a 2x2 table permitted the use of the Fisher test. The Fisher test is the most powerful of the one tailed-tests for data of the kind for which the test is appropriate (Siegel 1956). Where possible the group size categories were 1, 2, 3, and 4 and over (4+), and if chi-squared was not possible because of insufficient data in the cells then the 4+ and 3 categories were combined. If this still prevented the use of chi-squared, then the 3+ and the 2 categories were combined, and tested against the single-animal data. This was the most meaningful way of treating the data, as solitary individuals differ so much from groups behaviourally. In a

diverse range of species, the addition of one companion to a single animal has a great effect on its alertness; solitary individuals have been found to spend less time foraging and more time in surveillance than any other group size, for example curlews (Abramson 1979), bighorn sheep (Berger 1978), pronghorn antelope (Lipetz and Bekoff 1982), and modelled for birds (Caraco 1979).

Appendix 8 shows the actual numbers of animals and the percent of each seasons' total number of animals seen in each category. Table 7.1 shows the mean group size of each category and its range. Tables 7.2 and 7.3 show the way each data group was tested, and the result.

7.3 RESULTS

7.3.1 GROUP COMPOSITION

7.3.1.1 Mixed sex groups-single sex groups.

There were more animals in mixed-sex groups in autumn than at any other time of year ($P<0.001$: Table 7.2.1.a). Fifty percent of all animals seen in autumn were in mixed-sex groups. When autumn was removed from the contingency table there was no significant difference between the other three seasons (Table 7.2.1.b), when 16-18% of all animals were in mixed-sex groups in each season. (Fig 7.1).

7.3.1.2 Females without young-females with young: seasonal pattern.

Successive pairs of seasons were compared to see when major changes occurred. There were significantly more females with young in summer than there were in spring ($P<0.001$: Table 7.2.2.a). Seventy five percent of females had young in summer compared to 47% in spring. There were significantly fewer females with young in autumn than there were in summer ($P<0.001$: Table 7.2.2.b). Only 30% of females had young in autumn. There was no significant difference between autumn and winter (Table 7.2.2.c). There were significantly more females with young in spring than in winter ($P<0.02$:Table 7.2.2.d). Only 19% of females had young in winter. Fig. 7.2 shows the rise in the percent of all female groups seen that were with young from winter to spring to summer, and the drop from summer to autumn.

TABLE 7.1

Standard deviations, N, mean, standard errors, median and range of groupsizes of the different age/sex/season categories seen.O.M.=old males; Y.M.=young males; F.=Females without young; F.W.Y.=females withyoung; Mixed=mixed-sex groups.

	ST.DEV	N	MEAN	SEMEAN	MEDIAN	RANGE
Spring:						
O.M.	1.59	65	2.23	0.20	2.0	1-7
Y.M	1.50	21	2.19	0.33	2.0	1-7
F.	0.86	17	1.65	0.21	1.0	1-4
F.W.Y.	0.91	14	1.71	0.24	1.5	1-4
MIXED	1.83	12	4.08	0.53	3.5	2-8
Summer:						
O.M.	1.39	59	2.31	0.18	2.0	1-6
Y.M.	0.54	27	1.30	0.10	1.0	1-3
F.	0.99	21	1.76	0.22	1.0	1-4
F.W.Y.	1.69	50	2.24	0.24	2.0	1-8
MIXED	4.39	11	5.91	1.32	5.0	2-14
Autumn:						
O.M.	0.69	27	1.37	0.13	1.0	1-3
Y.M.	0.00	2	1.00	0.00	1.0	1
F.	1.00	7	2.00	0.38	2.0	1-4
F.W.Y	0.58	4	1.50	0.29	1.5	1-2
MIXED	1.41	18	3.28	0.33	3.0	2-7
Winter:						
O.M.	2.68	65	2.94	0.33	2.0	1-14
Y.M.	1.70	12	3.17	0.49	3.0	1-7
F.	1.26	16	1.87	0.31	1.0	1-5
F.W.Y.	0.55	5	1.40	0.24	1.0	1-2
MIXED	1.85	15	4.00	0.48	3.0	2-7

	STDEV	N	MEAN	SEMEAN	MEDIAN	RANGE
Whole year:						
Males	1.82	278	2.28	0.11	2.0	1-14
Females	1.30	134	1.93	0.11	1.0	1-8
Mixed	2.56	56	4.16	0.34	3.0	2-14
O.M.	1.92	216	2.37	0.13	2.0	1-14
Y.M.	1.38	62	1.95	0.18	1.5	1-7
F	1.02	61	1.79	0.13	1.0	1-5
F.W.Y	1.49	73	2.04	0.17	2.0	1-8
All animals	1.91	468	2.40	0.09	2.0	1-14
All animals:						
Spring	1.57	12	2.29	0.14	2.0	1-8
Summer	1.97	168	2.29	0.15	2.0	1-14
Autumn	2.24	58	2.03	0.29	2.0	1-7
Winter	2.34	113	2.89	0.22	2.0	1-14

TABLE 7.2

SUMMARY OF X2/FISHER TESTS ON THE GROUP DATA.

GS=Group size, Sp=spring, Su=summer, A=autumn, W=winter.

7.2.1.
Mixed sex groups (MSG) and single sex groups (SSG). Comparisons of animals in mixed or single sex groups in each season.

a.	SSG	MSG
Spring	246	49
Summer	320	65
Autumn	59	59
Winter	266	60
X2=69.11		
P<0.001		

b.		SSG	MSG
When autumn, the time of the rut is removed:	Spring	246	49
	Summer	320	65
	Winter	266	60
	X2=0.42		
	N.S.		

7.2.2.
Females with and without young: comparison of total numbers at different seasons.F=females without young; FWY=females with young.

Successive pairs of seasons

	a. F	FWY
Spring	28	24
Summer	37	112
X2=13.53		
P<0.001		

	b. F	FWY
Summer	37	112
Autumn	14	6
X2=19.28		
P<0.001		

c.	F	FWY
Autumn	14	6
Winter	30	7
X2=1.64		
N.S.		

d.	F	FWY
Winter	30	7
Spring	28	24
X2=5.92		
P<0.02		

7.2.3. Group sizes of males (M) and females (F) in different seasons.

a.Spring.

GS	M	F
1	37	16
2	46	22
3	30	6
4+	81	8
X2=16.05		
P<0.01		

b. Summer.

GS	M	F
1	43	33
2	40	34
3	33	39
4+	55	43
X2=2.27		
N.S.		

c.Autumn.

GS	M	F
1	22	4
2	8	12
3+	9	4
X2=10.11		
P<0.01		

d.Winter.

GS	M	F
1	26	12
2	42	10
3	24	6
4+	137	9
X2=19.38		
P<0.001		

7.2.4. Comparisons of group sizes of mixed and single sex groups in each season.

a.Spring

GS	SSG	MSG
2	68	4
3	36	12
4+	89	33
X2=13.79		
P<0.01		

b. Summer

GS	SSG	MSG
2	74	4
3	72	9
4+	98	52
X2=33.46		
P<0.001		

c. Autumn

GS	SSG	MSG
2	20	14
3	9	12
4+	4	33
X2=18.33		
P<0.001		

d. Winter

GS	SSG	MSG
2	52	8
3	30	12
4+	146	40
X2=3.62		
N.S.		

7.2.5.
Group sizes of females with (FWY) and without young (F).

a. All seasons pooled:

GS	F	FWY
1	31	34
2	38	40
3	15	36
4+	25	39

X2=5.84
N.S.

Each season separately:

b. Spring.

GS	F	FWY
1	9	7
2	12	10
3+	7	7

X2=0.12
N.S.

c. Summer.

GS	F	FWY
1	11	22
2	12	22
3	6	33
4+	8	35

X2=6.03
N.S.

d. Autumn.

GS	F	FWY
1	2	6
2+	12	4

Fisher:N.S. .

e. Winter.

GS	F	FWY
1	9	3
2+	21	4

Fisher:N.S.

7.2.6.
Group sizes of old (OM) and young (YM) males.
Each season separately:

a. Spring

GS	OM	YM
1	29	8
2	32	14
3	18	12
4+	69	12

X2=9.18
P<0.05

b. Summer

GS	OM	YM
1	23	20
2	28	12
3	30	3
4+	55	0

X2=36.93
P<0.001

c. Autumn

GS	OM	YM
1	20	2
2+	17	0

Fisher:N.S.

d. Winter

GS	OM	YM
1	25	1
2	34	8
3+	132	29

X2=3.47
N.S.

7.2.7.
Within-sex comparison of all seasons.

a. All males.

GS	Sp	Su	A	W
1	37	43	22	26
2	46	40	8	42
3	30	33	9	24
4+	81	55	0	137

X2=81.49
P<0.001

b. Old males only.

GS	Sp	Su	A	W
1	29	23	20	25
2	32	28	8	34
3	18	30	9	12
4+	69	55	0	120

X2=75.15
P<0.001

c. All females.

GS	Sp	Su	A	W
1	16	33	4	12
2	22	34	12	10
3	6	39	0	6
4+	69	55	0	120

X2=25.48
P<0.01

d. Females without young.

GS	Sp	Su	A	W
1	9	11	2	9
2	12	12	8	6
3+	7	14	4	15

X2=8.39
N.S.

7.3.
Within-sex comparisons between pairs of seasons.
7.3.1. Males.

Old males. Young males.

a.

GS	Sp	Su
1	29	23
2	32	28
3	18	30
4+	69	55

X2=5.04
N.S.

b.

GS	Sp	Su
1	8	20
2	14	12
3	12	3
4+	12	0

X2=21.60
P<0.001

c.

GS	Su	A
1	23	20
2	28	8
3	30	9
4+	55	0

X2=31.19
P<0.001

d.

GS	Su	A
1	20	2
2+	15	0

Fisher:N.S.

e.

GS	A	W
1	20	25
2	8	34
3	9	12
4+	0	120

X2=60.80
P<0.001

f.

GS	A	W
1	2	1
2+	0	37

Fisher:P<0.05

g.

GS	W	Sp
1	25	29
2	34	32
3	12	18
4+	120	69

X2=10.03
P<0.02

h.

GS	W	Sp
1	9	22
2	12	12
3+	17	12

X2=5.60
N.S.

7.3.2.
All females.

Females without young.
a.

GS	Sp	Su
1	9	11
2	12	12
3	3	6
4+	4	8

X2=1.31
N.S.

Females with young.
b.

GS	Sp	Su
1	7	22
2	10	22
3	3	33
4+	4	35

X2=8.53
P<0.05

c.

GS	Su	A
1	33	4
2+	116	16

X2=0.00
N.S.

d.

GS	Su	A
1	11	2
2+	12	8

Fisher: N.S.

e.

GS	Su	A
1	22	2
2+	90	4

X2=1.77
N.S.

f.

GS	A	W
1	4	12
2	12	10
3+	4	15

X2=8.3815 N.S.
P<0.02

g.

GS	A	W
1	2	9
2+	12	21

X2=2.23

h.

GS	A	W
1	2	3
2+	4	4

Fisher:N.S.

i.

GS	W	Sp
1	12	16
2	10	22
3	6	6
4+	9	8

X2=2.68
N.S.

j.

GS	W	Sp
1	9	9
2	6	12
3+	15	7

X2=4.85
N.S.

k.

GS	W	Sp
1	3	7
2+	4	17

Fisher:N.S.

7.3.3.
Mixed-sex groups: comparisons between pairs of seasons.

a.

GS	Sp	Su
2-3	16	13
4+	33	52

X2=1.7383
N.S.

b.

GS	Su	A
2	4	14
3	9	12
4+	52	33

X2=9.96
P<0.01

c.

GS	A	W
2	14	8
3	12	12
4+	33	40

X2=2.30
N.S.

d.

GS	W	Sp
2	8	4
3	12	12
4+	40	33

X2=0.90
N.S.

TABLE 7.4.
Summary of chi-square/Fisher tests of between-season differences of group size within age/sex classes.

	Old males	Young males	All females	Single females	Females with young	Mixed groups
SPRING-SUMMER:	N.S.	P<0.001	P<0.01	N.S.	P<0.05	N.S.
SUMMER-AUTUMN:	P<0.001	N.S.	N.S.	N.S.	N.S.	P<0.01
AUTUMN-WINTER:	P<0.001	P<0.05	P<0.02	N.S	N.S.	N.S.
WINTER-SPRING:	P<0.02	N.S.	N.S.	N.S.	N.S.	N.S.

TABLE 7.5
Mean, range, and mode of group sizes of wild sheep, including this study. N.A=not available, (M)=males, (F)=females.

Species	Mean group size	Range	Mode	Source
Urial (Pakistan)	2.9-12.7	1-50	N.A.	(Schaller 1977)
Argali (Afghanistan)	N.A.	1-50	11-20 (winter) 1-5 (summer)	(Petocz 1978)
Bighorn sheep	9.3	1-75	2-9	(Blood 1963)
Bighorn sheep	10.7	1-40	2-9	(Shackleton 1973)
Soay sheep (St. Kilda)	3.2	2-69 (F) 2-15 (M)		(Grubb 1974)
Mouflon (Cyprus)	2.4 (2.28 M) (1.93 F)	1-8 (F) 1-14 (M)		(this study)

7.3.2 GROUP SIZES

7.3.2.1 Male-female differences.

Males associated in larger groups than females in spring ($P<0.01$, Table 7.2.3.a) and in winter ($P<0.001$, Table 7.2.3.d). There was no significant difference between males and females in summer (Table 7.2.3.b). In autumn males were in smaller groups than females ($P<0.01$, Table 7.2.3.c). 56% of males were alone in autumn, compared with only 20% of the females. (Fig 7.3).

7.3.2.2 Mixed sex and single sex group sizes.

The group sizes 2, 3 and 4+ were tested for mixed sex and single sex groups for each season. Group size=1 was left out, because mixed groups are by definition two or more animals. The mixed groups were significantly larger than single sex groups in spring ($P<0.01$: Table 7.2.4.a); summer ($P<0.001$: Table 7.2.4.b; and autumn ($P<0.001$: Table 7.2.4.c. There was no significant difference between mixed and single-sex groups in winter (Table 7.2.4.d, Figs 7.4.a, 7.4.b, 7.5.a).

7.3.2.3 Group sizes of females without young and females with young.

There was no significant difference between group sizes of females with young and females without young when all seasons were pooled (Table 7.2.5.a), nor for each season examined separately (Tables 7.2.5.b, c, d, e, Fig. 7.7). For mean group sizes see Fig. 7.5.b.

7.3.2.4 Old males-young males.

When each season was examined separately, there was no significant difference between old and young males in autumn (Table 7.2.6.c), nor in winter (Table 7.2.6.d), but there were, however, significant differences in spring ($P<0.05$: Table 7.2.6.a) and in summer ($P<0.001$: Table 7.2.6.b). In spring 47% of older males were in groups of 4+ and younger males tended to be in groups of 2 or 3 (56% of all young males in spring). In summer there was a more marked difference: 57% of young males were on their own and a further 34% were in groups of two, whereas 40% of older males were in groups of 4+ and a further 22% were in groups of three. (Figs 7.6.a, 7.6.b) For mean group sizes see Fig. 7.5.c.

Fig. 7.1. Group composition: Percent of animals seen in mixed and single sex groups in each season.

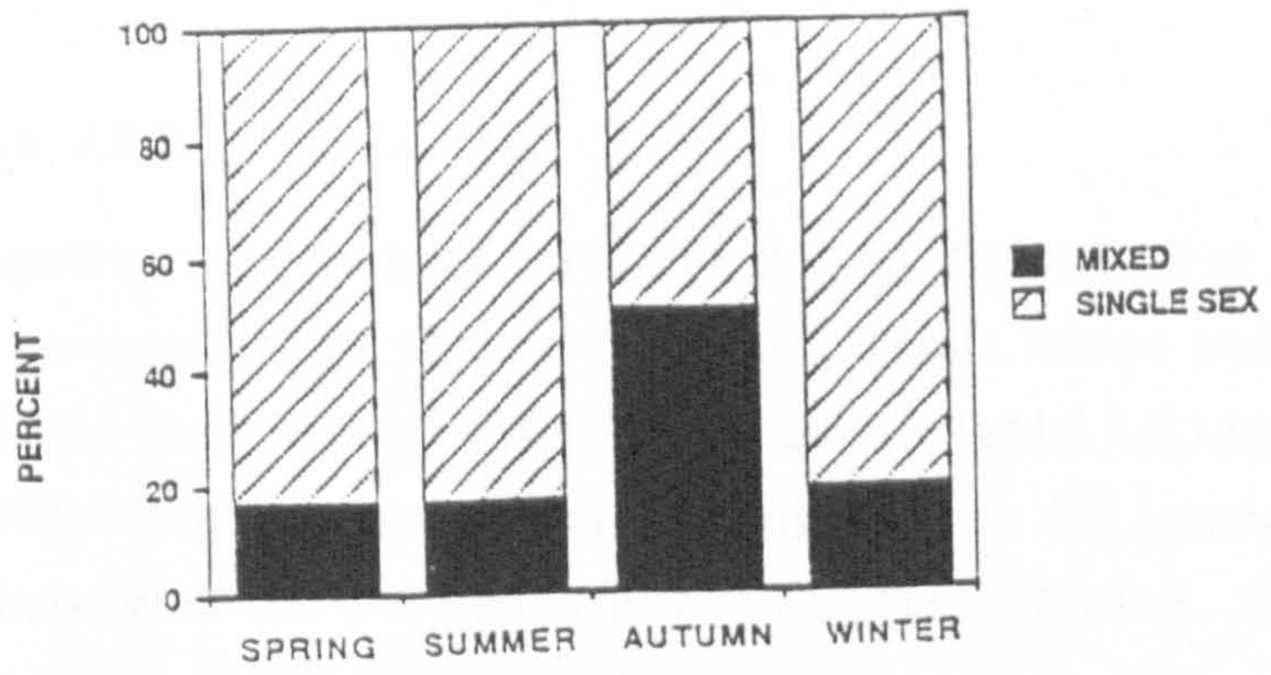


Fig. 7.2. Group composition: Percent of females in each season who were with young (FWY) and without (FNY).

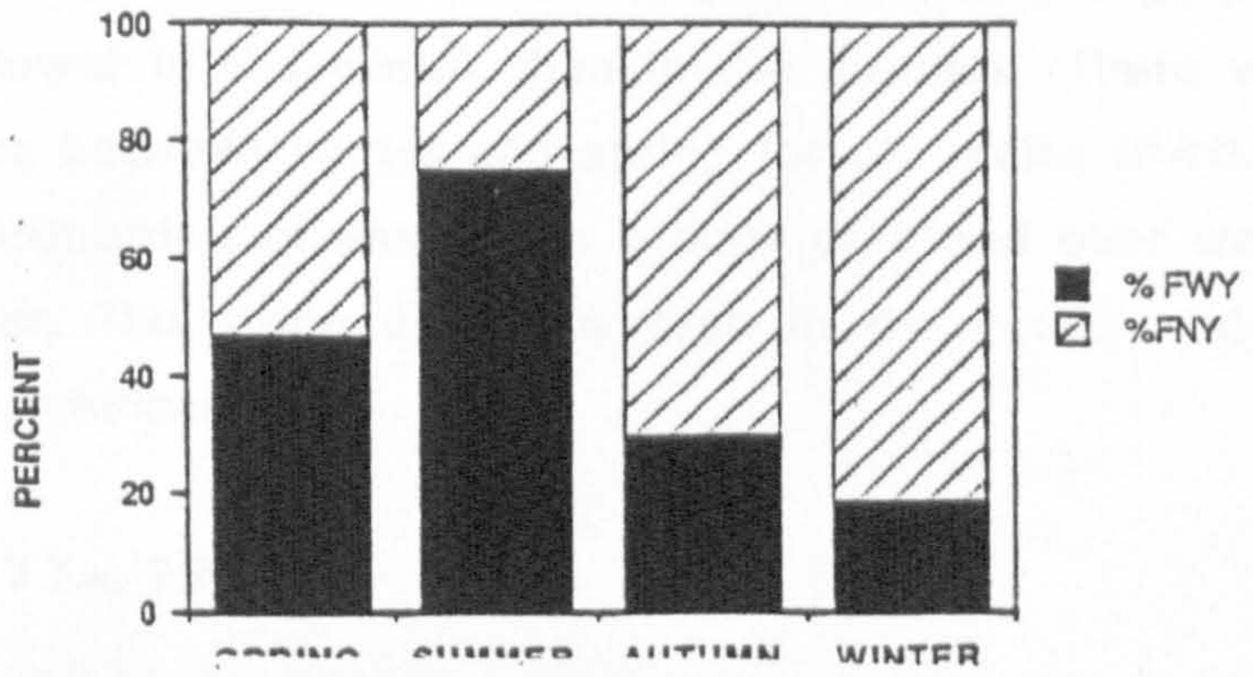
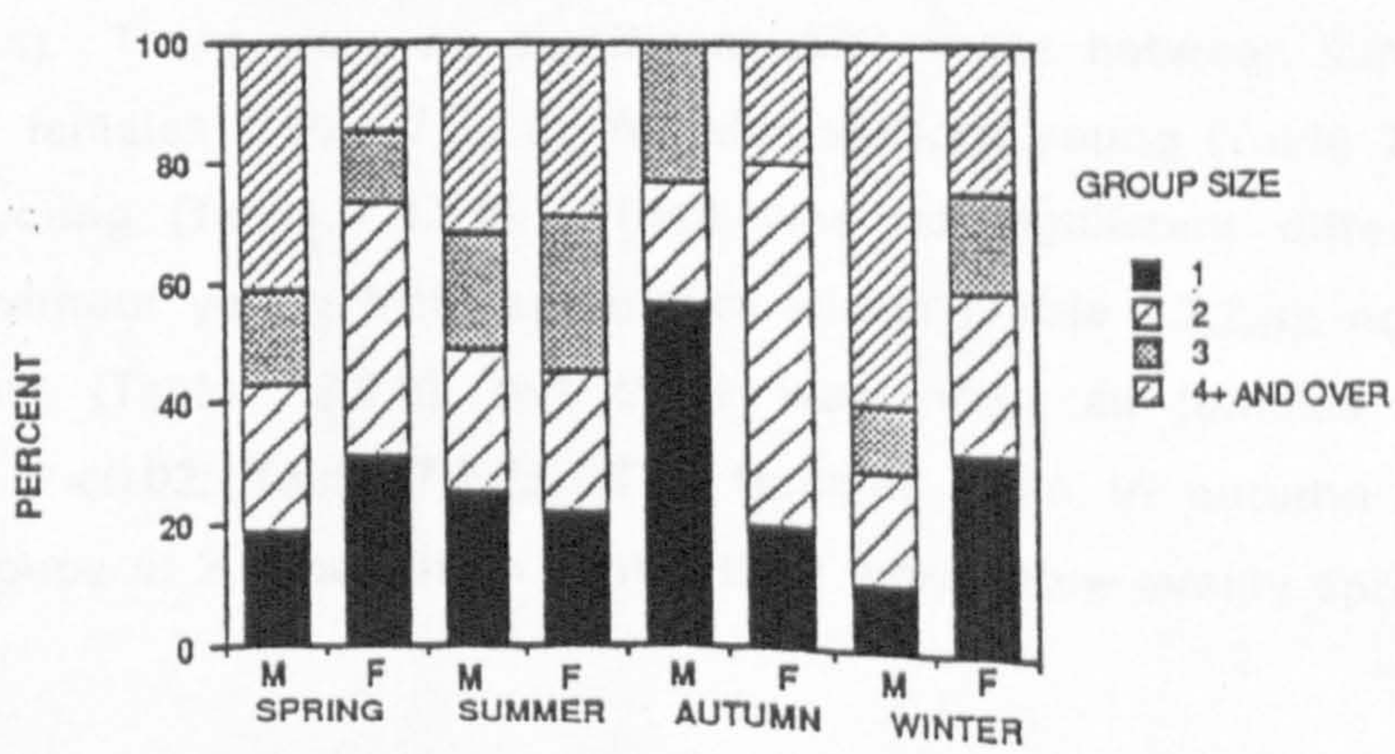


Fig. 7.3. Group sizes: Percent of animals seen in different group sizes in each season. Male-only groups (M) and female-only groups (F).



7.3.3 Pairs of seasons for intra-age/sex classes.

Changes in the grouping behaviour of each age/sex class were examined for successive pairs of seasons: spring vs. summer, summer vs. autumn, autumn vs. winter, and winter vs. spring. They were all arranged in contingency tables and chi-squared carried out on them except for where the Fisher test was appropriate (Siegel 1956) Table 7.4 shows a summary of the results.

7.3.3.1 Males. Fig 7.6.a, 7.6.b.

There was no significant difference between spring and summer for old males (Table 7.3.1.a). However, there were more young single males and groups of two in summer (91%) than in spring (48%) ($P<0.001$: Table 7.3.1.b). There was no significant difference between summer and autumn for young males (Table 7.3.1.d); but there was for old males ($P<0.001$: Table 7.3.1.c). This was because there was a higher proportion of old males alone or in groups of two in the autumn than in the summer. There were significant differences between autumn and winter for old males ($P<0.001$: Table 7.3.1.e); and young males ($P<0.05$: Table 7.3.1.f). In each case the proportion of animals in groups of 4 and over was much higher in winter than in autumn, and the proportion of animals alone was lower in the winter than in the autumn. There were also significant differences between winter and spring for old males ($P<0.02$: Table 7.3.1.g); where the proportion of animals in groups of 4 and over was less in spring than in winter. This trend could be seen in the young males (Table 7.3.1.h) but was not significant.

7.3.3.2 Females. Fig 7.7.a, 7.7.b.

The group sizes of females with young changed significantly from spring to summer ($P<0.05$: Table 7.3.2.b). There was a higher proportion of animals alone or in groups of two in spring than in summer, when there were more in groups of 3 and 4+. There was no significant difference for females without young (Table 7.3.2.a). There were no significant differences between summer and autumn for all females (Table 7.3.2.c); females without young (Table 7.2.d); or females with young (Table 7.3.2.e). There was no significant difference between females without young from autumn to winter (Table 7.3.2.g); nor for females with young (Table 7.3.2.h); but there was when all females were grouped together ($P<0.02$: Table 7.3.2.f). The females seen in autumn were mostly (60%) in groups of 2, whereas in winter they were more evenly spread

Fig. 7.4.a. Group sizes: Percent of animals in different group sizes in each season. Mixed-sex groups.

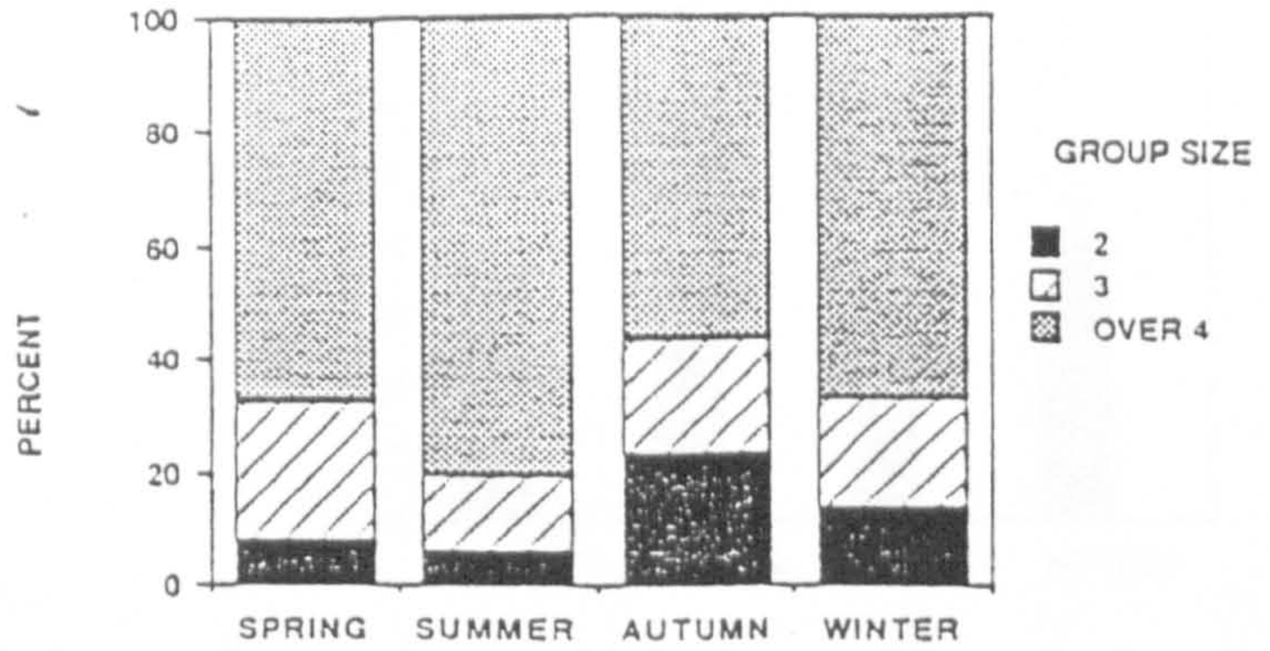
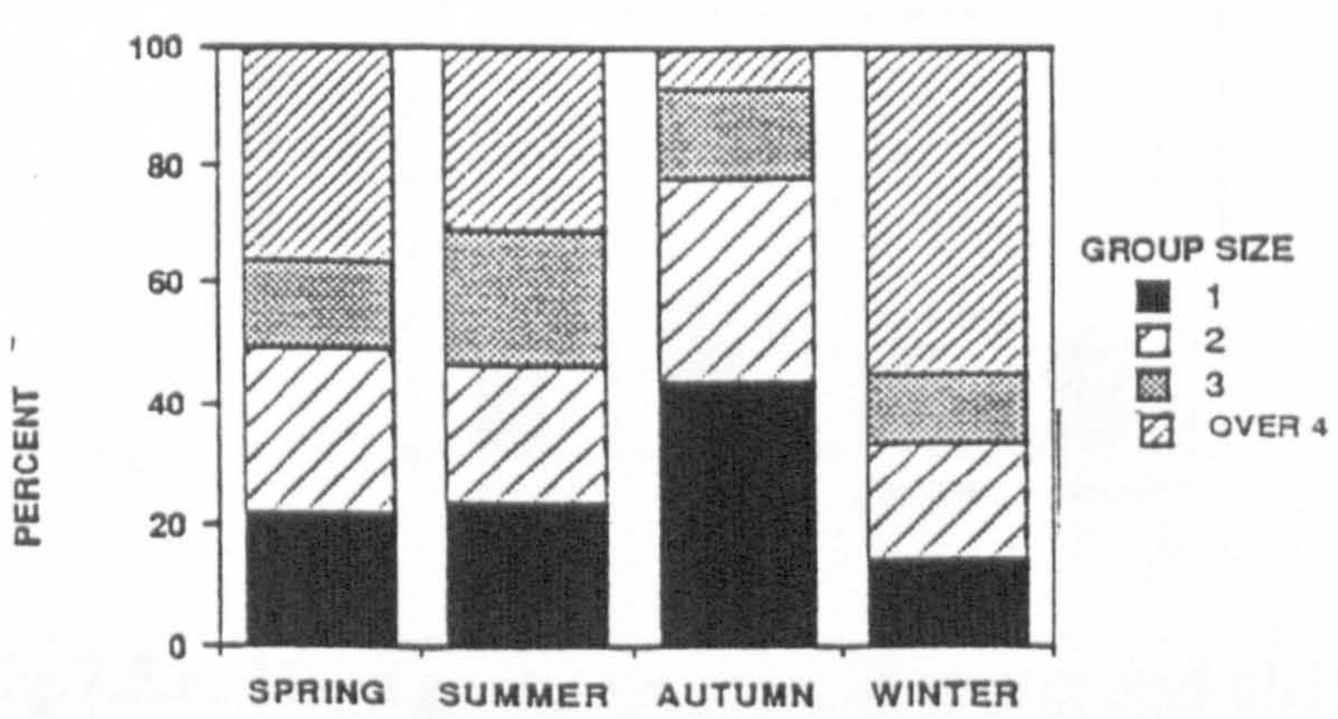


Fig. 7.4.b. Group sizes: Percent of animals in different group sizes in each season. Single-sex groups.



Mean group size±se. of groups of mouflon seen during the year.

Fig.7.5.a. Mean group size ±se. of mixed sex groups.

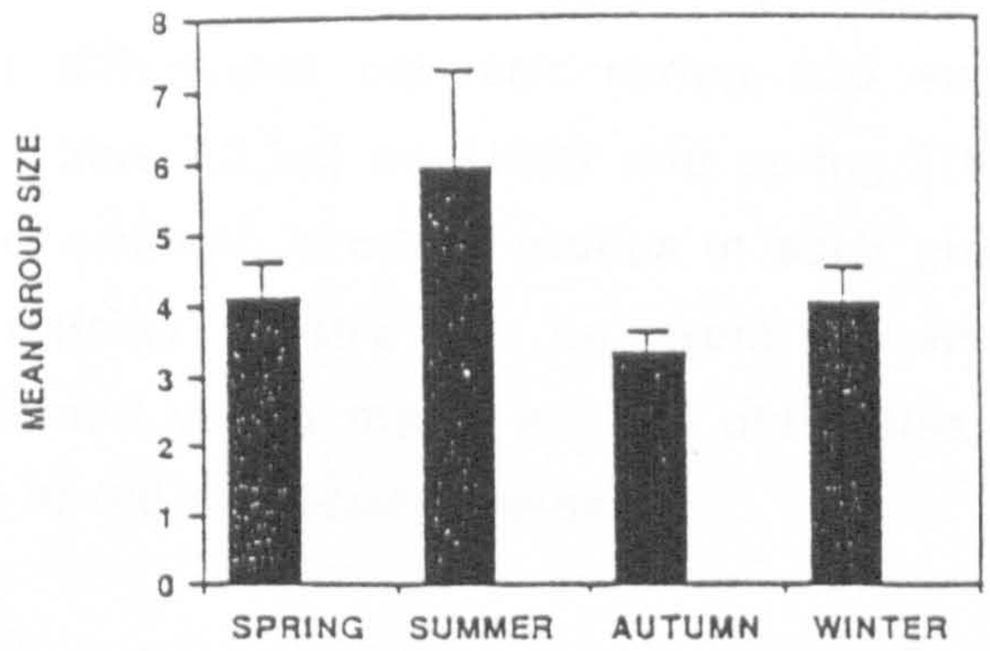


Fig.7.5.b. Mean group size ±se. of females with and without young.

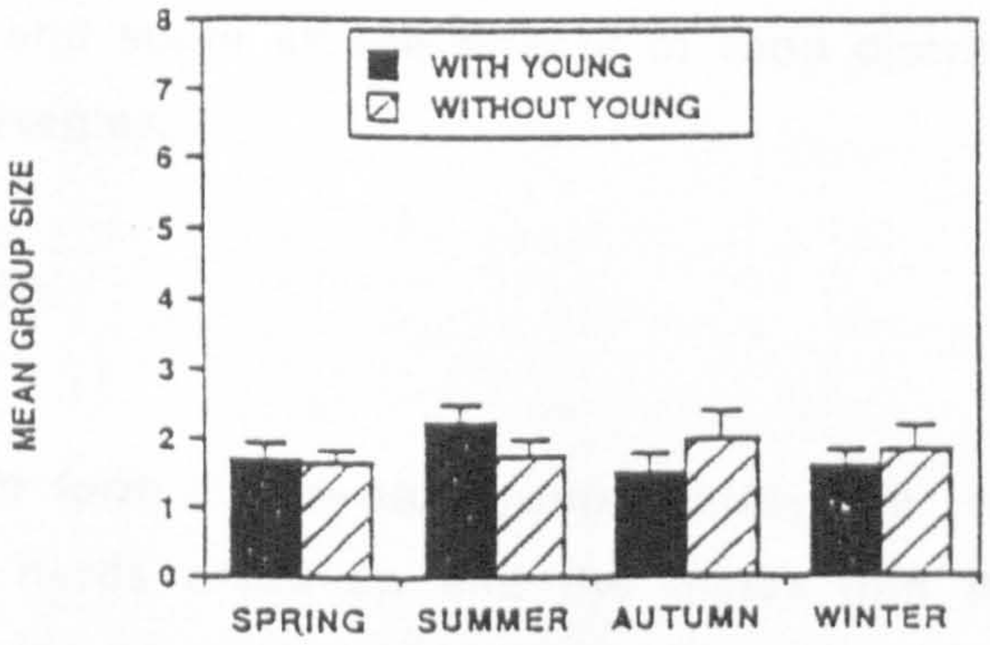
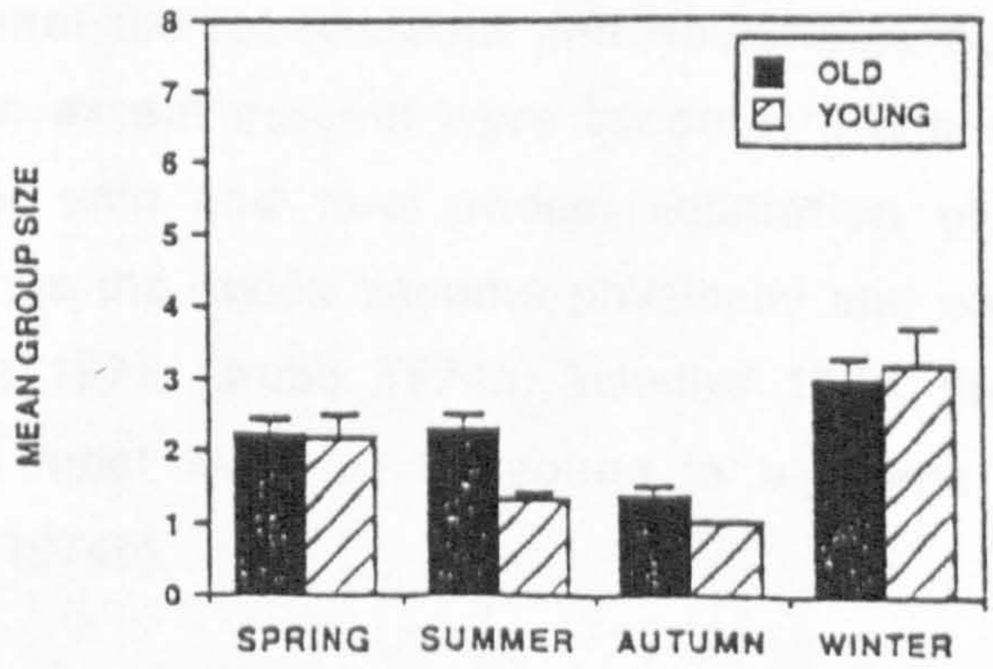


Fig.7.5.c. Mean group size ±se. of young and old males.



between the different group size categories. There was no significant difference between winter and spring for all females (Table 7.3.2.i); females without young (Table 7.3.2.j); nor for females with young (Table 7.3.2.k).

7.3.3.3 Mixed group size in different seasons.

Successive pairs of seasons were examined. The only significant difference between seasons was from summer to autumn ($P<0.01$: Table 7.3.3.b). There were no significant differences between spring and summer (Table 7.3.3.a) autumn and winter (Table 7.3.3.c) or winter and spring (Table 7.3.3.d). Fig 7.4.a shows the percent of animals in mixed groups in each group size category. Of all mixed groups outside of the rut; i.e. from December to the end of September, 21 contained young males and 14 old males, whereas only three contained a mixture of old and young males.

7.4 DISCUSSION

Of the above results, some can be categorised as mainly the effects of social organisation and some as the effects of food distribution or differences in anti-predator strategies.

7.4.1 Social grouping.

Other wild sheep form single-sex groups during the year except at the rut when the all-male herds break up and the males join the females on their home ranges: Stones sheep (Geist 1971); Bighorn sheep (Bunnell 1982, Geist 1971, Spencer 1943); Punjab urial (Schaller 1977); feral Soay sheep (Grubb & Jewell 1966, 1974, Jewell & Grubb 1974, Grubb 1974); and Corsican mouflon (Pfeffer 1967). Mouflon are similar to other wild sheep in that they were in single-sex groups until the rut (October and November). 82-84% of all animals seen in each season except autumn were accompanied only by animals of the same sex. In other wild and feral sheep, separation of young males from females takes place as the males become physically and socially dominant over adult females (Geist 1971, Grubb 1974a, Schaller 1977, Shank 1982). Males in mixed groups were most likely to be young in bighorns (Geist 1971) and in Soay sheep (Grubb 1974b).

At the rut, mouflon also followed the pattern of other wild sheep: 50% of all animals seen were in mixed sex groups. Male groups were also smallest at this time: 56% of all males seen in autumn were alone and a further 21% were in twos. There were no groups of four or more. Thus it appeared that the big male groups seen in the rest of the year fragmented into single animals or twos, who moved between the female groups. Male Soay sheep were often noted to be in groups of two during the early rut (Grubb 1974b). Punjab urial males were in small groups during the rut (Schaller 1977, Schaller & Mirza 1974), and many male Corsican mouflon were solitary at this time (Pfeffer 1967). The sizes of the mixed groups that formed during the rut were significantly smaller ($P<0.01$) than those in summer. In fact, the biggest mixed groups occurred in summer, the smallest in autumn. Mixed groups were always bigger than single sex groups in all seasons, often containing four or more animals. This is also true of Spanish ibex (Alados 1985b), Punjab urials (Schaller 1977), fallow deer *Dama dama* (Jodra 1981) and mule deer (Koutnik 1981). Of course, this would be more likely to happen if single male and single female animals were included in the analysis, as a mixed group cannot have fewer than two members. Even when the single animals were excluded, single sex groups were still significantly smaller than mixed sex ones except in winter.

Throughout the summer the mouflon lambs became stronger and more independent. The sharp drop in the proportion of females accompanied by young from summer to autumn indicates that many young left their mothers at this time, or died, or both. Lambs may have died in their first summer due to the poor forage quality. In general, both in wild sheep and wild goats, the young are weaned by 4-5 months, by the time of the rut, when almost all suckling ceases (Geist 1971, Schaller 1977, Shackleton & Shank 1984). The breakdown of the close mother-young bond is gradual, and although males usually leave their mothers' home range the females often stay (Shackleton & Shank 1984). For example, Grubb (1974a) noted that ewe groups of Soay sheep comprise related individuals, and Geist (1971) recorded that female bighorn sheep lambs usually stay on the range of their mothers, but that the males tend to leave. Thirty percent of female Cyprus mouflon were accompanied by young during the autumn, and 19% in winter, so these were possibly the female lambs.

7.4.2 Group size.

7.4.2.1 Predation effects.

There may be a difference in vulnerability to predators between males and females: males are larger and 20% heavier than the females. Males weigh 50-55 kg and females weigh 40-45 kg. Males are armed with horns, whereas females are hornless. Furthermore females have young at foot from March/April onwards, which for the first few months of their lives are smaller and less experienced than the adults. From November onwards females are pregnant, which may also slow them down in flight from enemies.

Subjectively, males were more conspicuous than females to the observer, because of their horns and their more contrasting coats: females are brown; males are brown, black and white (see Figs 1.6 and 1.7). A conspicuous, less vulnerable animal can perhaps afford to go about in larger groups than a more vulnerable inconspicuous one if there is some additional advantage to being in a larger group. Females may not be able to afford to be in such large groups as the males because they are more vulnerable, and may attain a lower level of conspicuousness by reducing group number. The least conspicuous group size is presumably one, yet only 30% of females were seen alone during any season. This means that 70% of all the females seen had at least one companion. The difference between one animal and two has been shown to be greater than that between two and three animals in terms of reducing the amount of time spent in vigilance and in increasing the amount of time spent foraging (Lipetz and Bekoff 1982). Therefore the females seem to be in the smallest but safest groups possible. Over the whole year, females were in groups of 1-8 (median=1); which was smaller than male groups, who ranged from 1-14 animals (median=2). Groups of five females or more were rare: only 11% of all females were in groups of this size. Female Soay sheep were rarely in big groups either: only 6.8% were in groups of four or more (Grubb 1974a).

In general, males were in bigger groups than females except during the rut. There may be an important element of social interaction within the male groups as they must learn the relative strengths and weaknesses of their colleagues before the rut, when there is competition for access to females. This would be advantageous to each individual in that he would know whom he could challenge with some chance of success during the rut itself without

sustaining damage or wasting energy: an assessment of risk. Red deer assess each others' strength by roaring (Clutton-Brock et al. 1979, Clutton-Brock and Albon 1979).

In mouflon, female group size was significantly higher in summer than in spring for females with young at foot, but there was no difference between spring and summer group size in barren females. Females therefore seem to group together more in the summer when they have young at foot. This may be a function of the fact that more females are alone in the spring when they give birth, and re-form into groups when their young are older. Sheep and goats both isolate themselves in cliff habitat to give birth, for example Sardinian mouflon (Pfeffer 1967), feral goats (Rudge 1970), Bighorn sheep (Geist 1971), Stones' sheep (Geist 1971), Soay sheep (Grubb 1974a), Punjab urial (Schaller 1977), as did Cyprus mouflon in the present study. This not only acts as an antipredator measure- the cliffs are extremely steep and inaccessible- but it has also been suggested that it allows the mother to form a bond with her offspring in the absence of other females (Arnold and Dudzinski 1978). Punjab urial (Schaller 1977), Corsican mouflon (Pfeffer 1967) and possibly bighorn sheep (Geist 1971) keep the lamb separate from other sheep for up to 7 days.

7.4.2.2 Forage effects.

Grasses tend to be less patchily distributed than browse species. Grasses grow in a highly synchronised manner following substantial rain and dry out evenly within a fairly short period when the rainy season ends. However, browse species, especially woody ones, while often showing a spurt of growth immediately following rain, tend to continue growing small shoots, leaves, flowers and fruits long after the growth of grasses has ceased. (Leuthold 1977). Freshly produced browse items are thus available when grasses are at or near their lowest level of nutrient quality. Browse items usually contain less fibre than grasses, i.e. more directly utilisable nutrients than grasses. (Leuthold 1977) but once browsed have a longer recovery time than for grasses due to the fact that grasses grow continually from ground level (in the leaf sheath).

The seasonal differences in the size of male groups outside the rut may reflect forage differences. Groups of males were significantly larger in winter

than at other times of year. Winter is a time of plenty in Cyprus, when the rain brings new growth of plants. Grasses and forbs grow in clearings on the forest in winter, providing widely separated high-biomass feeding areas. In winter, it may therefore be better or more efficient to remain in big groups, so that males can stay together, thus enhancing predator detection and social interactions. In summer, when the ground layer dries up, browse becomes more important. This is widely scattered and this may force the break-up of the large winter groups.

Old males tended to be in larger groups than the young males during spring and summer, possibly because some of the younger males were returning to mixed groups at this time. Certainly the biggest mixed groups were seen in summer.

The females have to ensure that they are in sufficiently good condition to bear young and to provide them with enough milk until they are weaned. Females may require to keep discrete home ranges that they know well and can exploit systematically in order to provide a predictable food supply during the dry period from May to November when both the provision of milk for the young and the declining quality of the forage are acting together to make this perhaps the most physiologically demanding period of the year. This would be a factor that would tend to reduce group size to the smallest units feasible. No wild sheep have been observed to defend territories, but they all keep home ranges (Shackleton & Shank 1984). Soay sheep adhered to their home ranges very closely (Grubb & Jewell 1974), if two groups grazed one patch of sward they tended to do so at different times. Female sheep usually inherit the home range pattern from the ewe band in which they were born and raised (Geist 1971).

7.4.2.3 Forest effects.

Mean group size for urials, argalis, bighorn and Soay sheep are all greater than that of mouflon (Table 7.5) All these other sheep live in open habitat. The range of group sizes is also much greater in these other sheep than in mouflon. Schallers' data for group sizes of Punjab urial (Schaller 1977) followed roughly the same seasonal pattern of group size variation for males, females, and mixed groups as Cyprus mouflon, except that urial group size was

about double that of mouflon (Fig 7.8). Mouflon thus seem to fall into the pattern of other ungulate forest dwellers. Sardinian and Corsican mouflon used forest in preference to open country when they were introduced into new areas in Europe, but when urials were introduced into their herds, the mouflon started to use open habitats (Turck & Schminke 1965). It is possible that mouflon in the wild use forest as a refuge from humans, but given the chance, prefer open land.

7.5 SUMMARY

1. Mouflon, like other wild sheep, are mostly in single-sex groups during the year, except during the rut.
2. Male groups are smallest during the rut. It is presumed that they are travelling between female groups to find those in oestrus, as do other wild sheep.
3. Male groups are bigger than female groups. This is discussed with reference to the differing vulnerability and conspicuousness of males and females, and to the requirement of females for a predictable food supply.
4. Females with young are in smaller groups in spring than in summer. This is thought to be because females giving birth are solitary, but form groups when the young are a little older.
5. Male groups are smaller in spring and summer than in winter. This may be connected with the forage distribution in the dry and wet seasons.
6. The overall group sizes are smaller than all other species of wild sheep. Forest dwelling is considered to reduce group sizes in other ungulates and appears to have done so here.

Fig. 7.6.Group sizes: Percent of males in different group sizes in each season.

Fig 7.6.a. Old males.

Fig. 7.6.b. Young males.

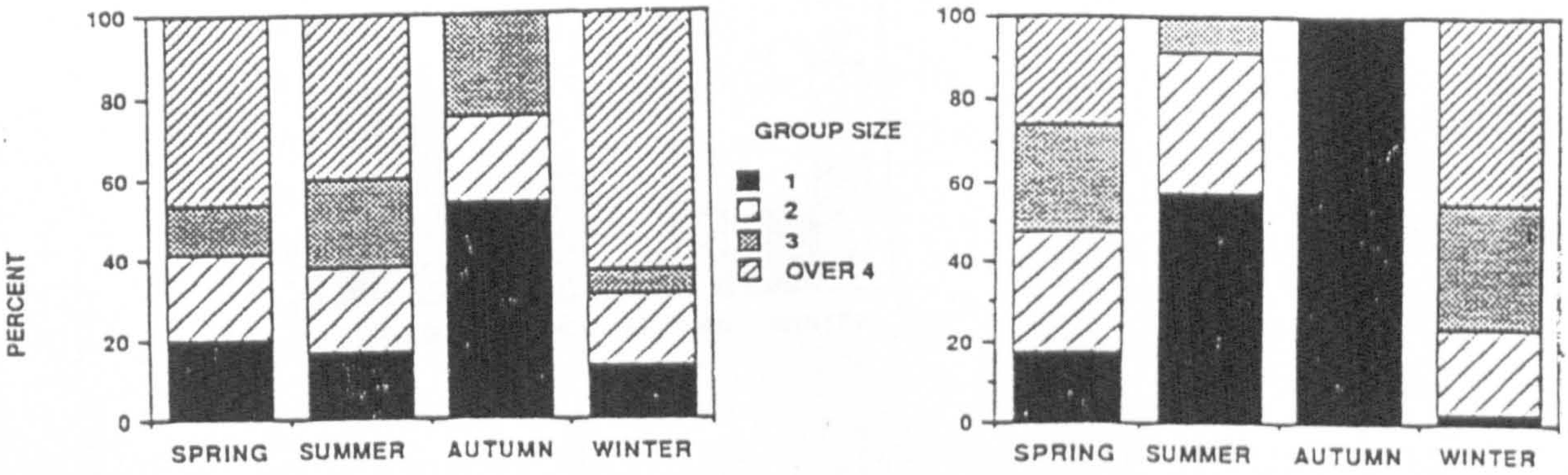


Fig. 7.7.Group sizes: Percent of females in different group sizes in each season.

Fig. 7.7.a. Females with young.

Fig. 7.7.b. Females without young.

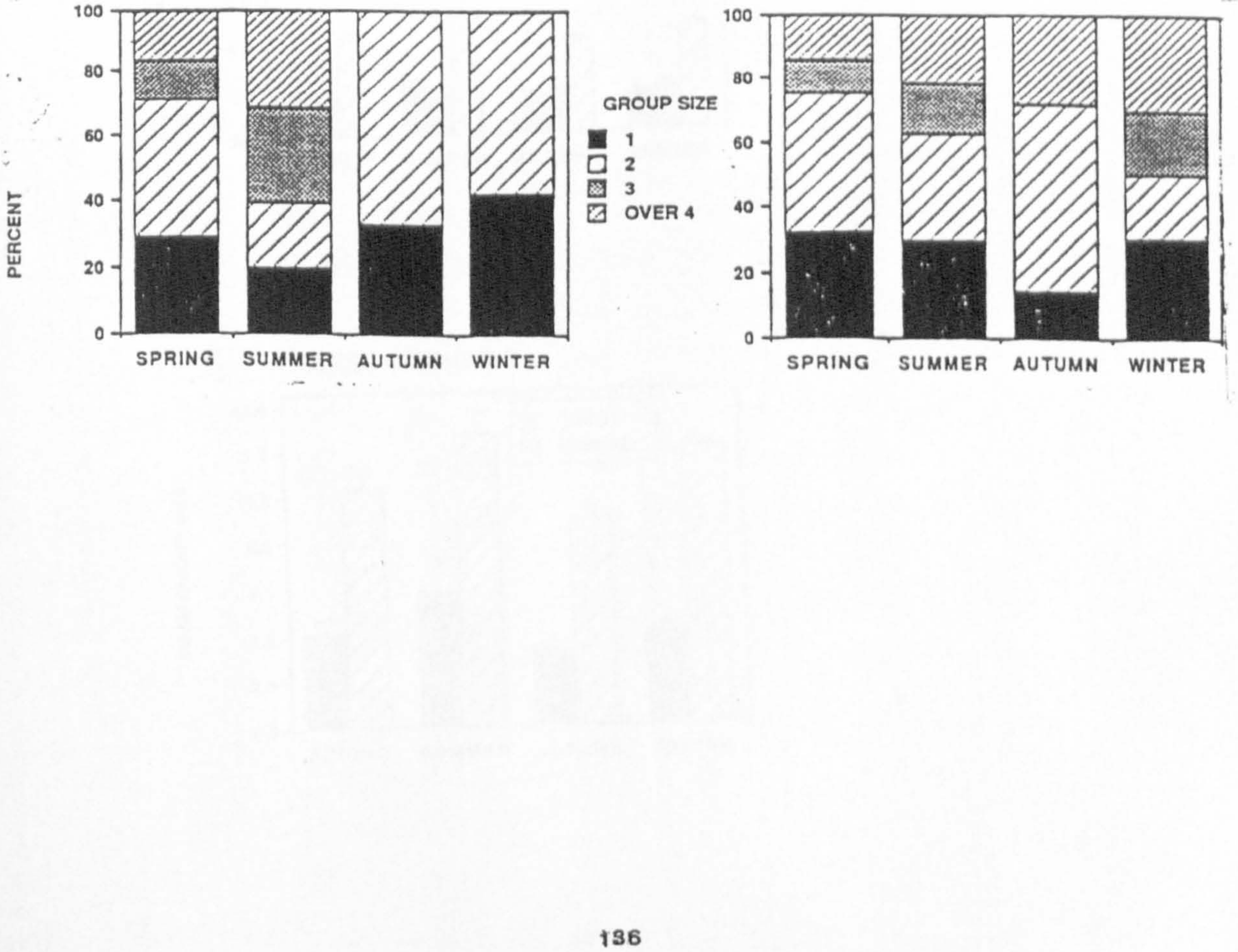
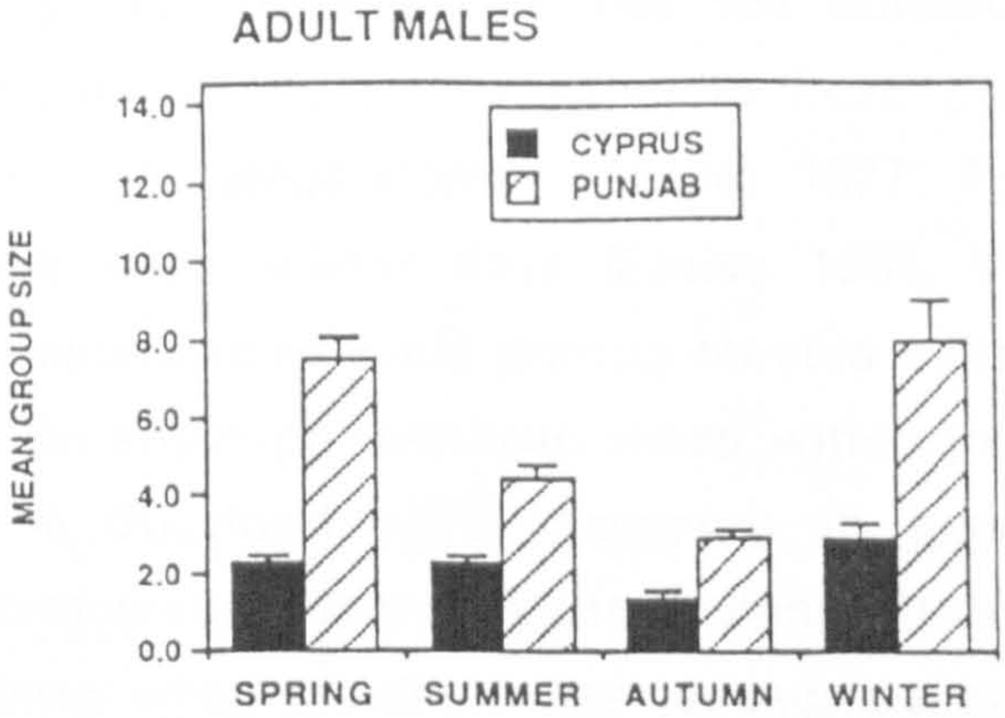
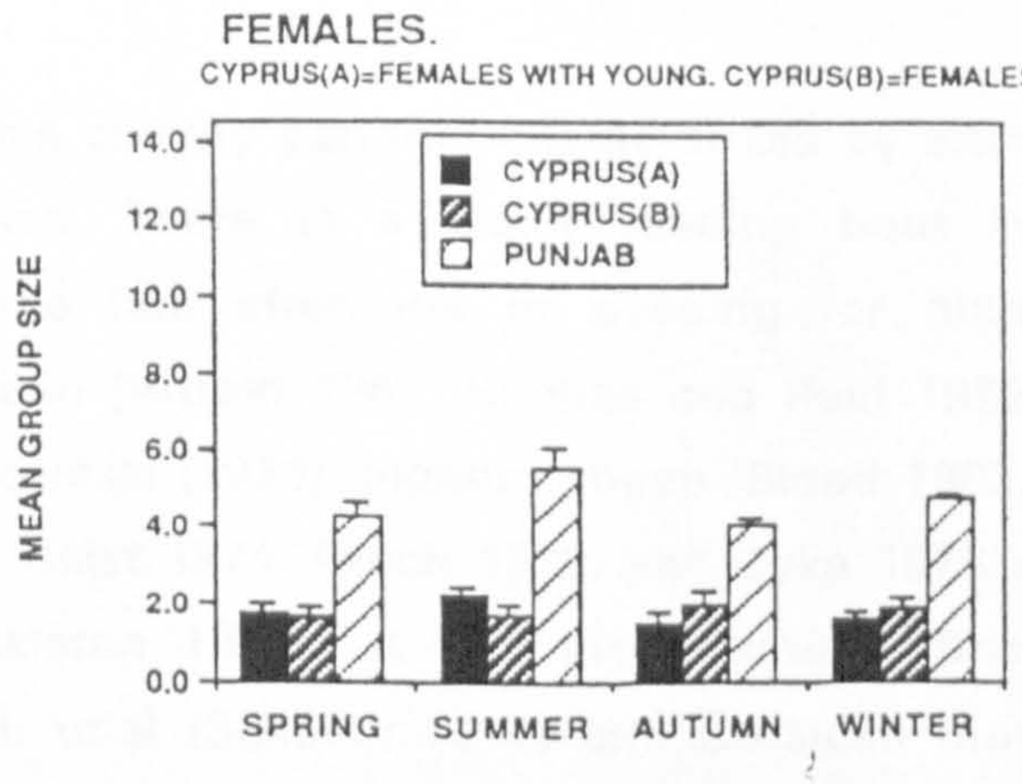
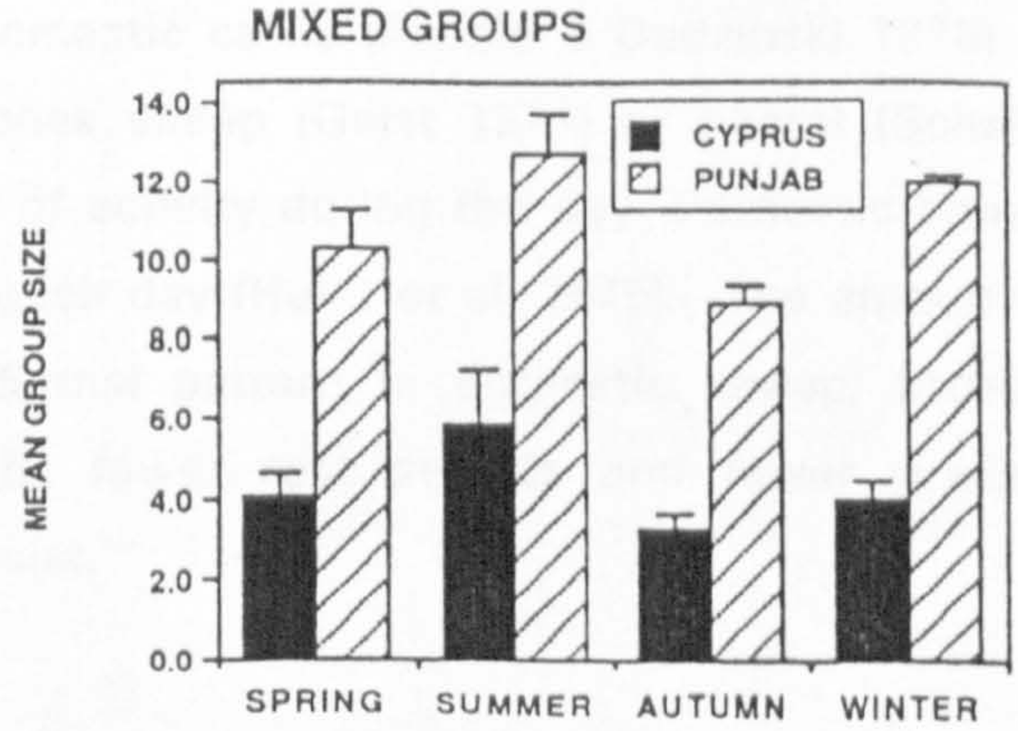


Fig 7.8

Mean group sizes of Cyprus mouflon (this study) and Punjab urial (Schaller 1977).







CHAPTER 8
SEASONAL FEEDING PATTERNS

8.1 INTRODUCTION

Because of the Mediterranean climate of Cyprus, the time of year when food was of poorest quality was also the hottest, driest season. Although sheep are physiologically well adapted to heat, (Schmidt-Nielsen 1964) wild species avoid high temperatures (Schaller 1977: Punjab urial) but may feed throughout the short winter days (Eccles 1981, Van Dyke 1978: bighorns). Stones sheep appeared to avoid grazing on cold mornings (Geist 1971) but cold did not have an effect on domestic sheep within the temperature range -7 to 9°C (Arnold & Dudzinski 1978). However, in general, domestic sheep are sensitive to temperature, humidity and daylength (Arnold & Dudzinski 1978). By noting the times when mouflon were feeding during different seasons, it was hoped to collect information on whether they were avoiding extremes of temperature by restricting their activity to the mildest times of day in any season.

Sheep have activity patterns characterised by alternate bouts of feeding and rest-rumination. There is a major feeding bout in the early morning and another in the late afternoon or evening for many sheep, for example in domestic sheep (Arnold 1962, Hughes and Reid 1952, Squires 1971, review by Arnold & Dudzinski (1978), bighorn sheep (Blood 1963, Chilelli & Krausman 1981, Eccles 1981, Geist 1971, Olech 1979, Van Dyke 1978 and Welles & Welles 1961; review Shackleton 1985). It was also found in Soay sheep (Grubb & Jewell 1974), Punjab urial (Schaller 1977) and Corsican mouflon (Pfeffer 1967). Some other Caprinae species also share this activity pattern: chamois (Pachlatko & Nievergelt 1985) saiga *Saiga tatarica* (Heptner et al. 1966) and markhor *Capra falconeri*, Himalayan tahr *Hemitragus jemlahicus* and wild goats (Schaller 1977), and so do domestic cattle (Arnold & Dudzinski 1978). However, this was not the case for Stones sheep (Geist 1971) or bharal (Schaller 1977) which had three major peaks of activity during the day. Domestic sheep feed for a total of about 9-11 hours each day (Hulet et al. 1975). The amount of food available does not affect the diurnal pattern in domestic sheep; (Arnold 1962): if food is short there may be fewer rest periods and fewer grazing periods but the major patterns persist.

8.2 METHODS

Observations were made from two main observation points, Vroisha and Koppes. These areas were watched from fixed viewing points, and mouflon were continuously recorded as grazing, walking, lying or standing, over periods of from one to ten hours. The group sizes and the sexes were always noted. All times were adjusted to Cyprus Summer Time for the figures and tables, (i.e. the winter times were adjusted accordingly). During evening observation sessions, animals were watched until it became too dark to see. 10x40 binoculars and a 25-60x telescope were used.

It soon became obvious that animals were more conspicuous when grazing, walking and standing than when lying down. This was due to the uneven nature of the ground and the height of the shrub layer, which often concealed lying animals. Thus lying down must have been underestimated. Therefore it was decided to classify grazing and walking animals as "Actively feeding" as walking was usually between grazing spots. Animals often ruminated whilst standing. The grazing pattern could then be determined from the "actively feeding" data, and the gaps where there was no grazing was assumed to be when animals were ruminating or resting. This rather patchy method of recording activity was necessary because of the difficulty of observation due to the nature of the terrain (broken, craggy ground) and the vegetation (forest).

The seasons were defined as follows:

Spring: March, April, May. Rainfall 25-100mm/month. Temperature 10-20°C.

Summer: June, July, August, Sept. Rainfall <25mm/month. Temperature 20-32°C.

Autumn: October, November. Rainfall 50-77 mm/month. Temperature 10-20°C.

Winter:December, Jan., February. Rainfall 150-255mm/month. Temperature <10°C.

Each hour of the day of each season was examined separately. For each hour, the total number of days on which observations were made was recorded

as N. The number of times that one or more animals were seen active during that hour was expressed as a proportion of the total N (Table 8.1, Figs 8.1–8.4). Males and females were analysed separately. One animal or a group were given equal weighting in these cases, because sheep tend to synchronise their activity patterns (Arnold & Dudzinski 1978).

8.3 RESULTS

8.3.1 Spring

There was a marked diurnal rhythm in feeding activity. (Fig. 8.1.a). The animals grazed from dawn until 1100 h, rested until 1300–1400 h, then started to feed again. There was a strong peak in feeding from 1800 h until darkness fell (2000 h).

8.3.2 Summer

There was an even more marked mid-day lull in activity. (Fig 8.2.a). Animals fed from dawn until 0800 h (females) (Fig 8.2.c) or 1000 h (males) (Fig 8.2.b), rested until 1200–1300 h, then fed again until darkness fell (2100 h).

8.3.3 Autumn

A morning peak of activity was followed by a short mid-day rest, and grazing resumed in the afternoon (Fig. 8.3.a). Although it appeared as if males were resting later than the females, (Figs 8.3.b and c), the sample sizes were too small to be sure.

8.3.4 Winter

A slight lull in activity at mid-day broke up the fairly regular grazing pattern (Fig. 8.4.a). The morning feeding period peaked at 0900–1100 h, well after dawn. The evening feeding bout peaked at 1700 and then activity fell. N=1 for late evening (1900 and 2000 h) so the apparent peak of males (Fig 8.4.b) and all animals and corresponding trough for females (Fig 8.4.c) is an artefact.

Table 8.1
Daily feeding patterns.

a=no. of days on which mouflon were seen feeding.
b=no. of days on which males were seen feeding.
c=no. of days on which females were seen feeding.
N=total no. of days observed.
Male group size, female group size=size of each group seen.

MARCH, APRIL, MAY.

Time of day	a	b	c	%a	%b	%c	N	Male group size	Female group size
0600-0700	4	4	0	80	80	0	5	2,3,3,5	
0700-0800	4	4	2	75	75	33	6	2,2,3,3	2,3
0800-0900	4	1	3	80	20	60	5	3	1,2 11
0900-1000	5	2	4	71	29	57	7	1,3	1,1,4,11
1000-1100	4	2	2	100	50	50	4	5,7	3,1
1100-1200	1	0	1	20	0	20	5		3
1200-1300	0	0	0	0	0	0	6		
1300-1400	0	0	0	0	0	0	6		
1400-1500	1	0	1	12	0	12	8		1
1500-1600	4	4	0	40	40	0	10	1,1,5,5	
1600-1700	4	4	0	40	40	10	10	1,2,2,5	2
1700-1800	6	6	0	50	50	0	12	2,2,2,4,9,29	
1800-1900	10	10	0	83	83	0	12	1,1,1,2,2,2,4,4,5,26	
1900-2000	6	6	0	75	75	0	8	1,2,2,4,4,5	

JUNE,JULY,AUGUST,SEPTEMBER.

Time of day	a	b	c	%a	%b	%c	N	Male group size	Female group size
0500-0600	2	0	2	30	0	30	6	1,1	
0600-0700	4	3	2	57	43	29	7	1,2,4	1,1
0700-0800	2	1	2	30	17	30	6	5	1,2
0800-0900	1	1	0	33	33	0	3	1	
0900-1000	1	1	0	50	50	0	2	1	
1000-1100	0	0	0	0	0	0	2		
1100-1200	0	0	0	0	0	0	6		
1200-1300	*	*	*	*	*	*	0		
1300-1400	1	0	1	14	0	14	7		2
1400-1500	1	1	1	11	11	11	9	1	1
1500-1600	2	1	1	12	6	6	17	1	1
1600-1700	8	4	5	31	15	19	26	1,2,3,6	1,2,2,3,9
1700-1800	11	8	4	41	30	15	27	1,1,1,1,2,2,4,6	1,2,3,7
1800-1900	18	11	9	64	39	32	28	1,1,1,1,1,1,2,2,2,5,6	1,1,1,1,1,2,2,2,5
1900-2000	16	11	6	59	41	22	27	1,1,2,2,3,3,3,4,5,5,6	1,1,1,2,3,6
2000-2100	12	9	4	75	56	25	16	1,1,1,1,3,3,3,3,4	1,1,1,2

OCTOBER AND NOVEMBER

Time of day	a	b	c	%a	%b	%c	N	Male group size	Female group size
0600-0700	2	2	0	66	66	0	3	1,2	
0700-0800	3	3	3	100	100	100	3	1,2,2	2,3,5
0800-0900	1	1	1	33	33	33	3	2	5
0900-1000	1	0	1	33	33	33	3		1
1000-1100	1	0	1	33	0	33	3		1
1100-1200	1	0	1	33	0	33	3		2
1200-1300	0	0	0	0	0	0	4		
1300-1400	1	1	0	20	20	0	5	1	
1400-1500	2	2	0	40	40	0	5	1,2	
1500-1600	1	1	0	17	17	0	6	2	
1600-1700	1	1	1	20	20	20	5	1	1
1700-1800	1	1	1	25	25	25	4	1	1

DECEMBER, JANUARY, FEBRUARY.

Time of day	a	b	c	%a	%b	%c	N	Male group size	Female group size
0700-0800	2	2	0	29	29	0	7	1,2	
0800-0900	8	8	1	73	73	9	11	1,1,2,3,4,5,5,10	1
0900-1000	10	8	4	67	53	27	15	1,2,2,3,3,3,3,6	1,1,2,3
1000-1100	13	9	5	76	53	29	17	1,1,1,1,2,2,2,3,13	1,2,2,2,2
1100-1200	14	9	7	61	35	30	23	1,2,2,3,4,4,5,6,8	1,1,1,1,2,2,5
1200-1300	7	4	5	30	17	22	23	1,4,7,8	1,1,1,2,2
1300-1400	11	9	6	50	41	27	22	1,1,1,1,1,1,3,4,6	1,1,2,2,2,3
1400-1500	13	11	5	62	52	24	21	1,1,1,1,2,2,2,2,3,4,5	1,1,1,2,4
1500-1600	10	10	4	45	41	18	22	1,1,2,2,2,4,4,5,7,8	1,2,2,4
1600-1700	11	10	4	55	50	20	20	1,2,2,3,6,7,7,8,11,11	1,1,3,10
1700-1800	12	11	4	80	73	27	15	1,1,2,2,3,3,4,5,5,8,17	1,1,2,3
1800-1900	1	1	0	25	25	0	4	2	
1900-2000	1	1	0	100	100	0	1	7	
2000-2100	1	0	1	100	0	100	1		1

Percent of total observation hours that mouflon were seen feeding.

Fig 8.1. Spring. (March, April, May.)

Fig 8.1.a. All animals.

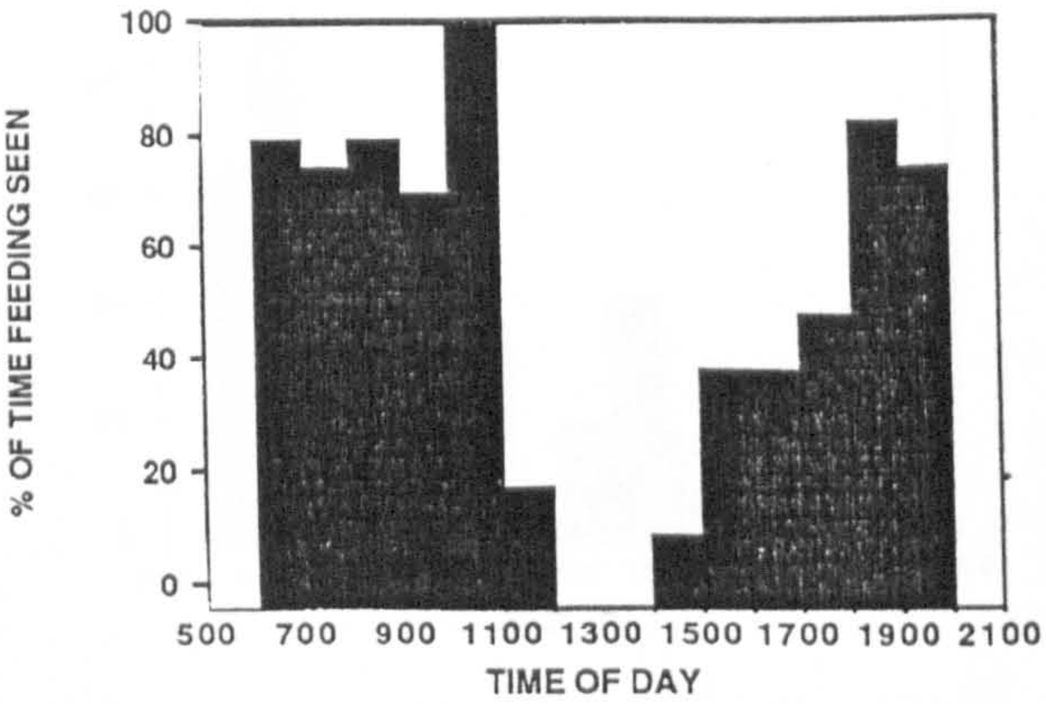


Fig 8.1.b. Males.

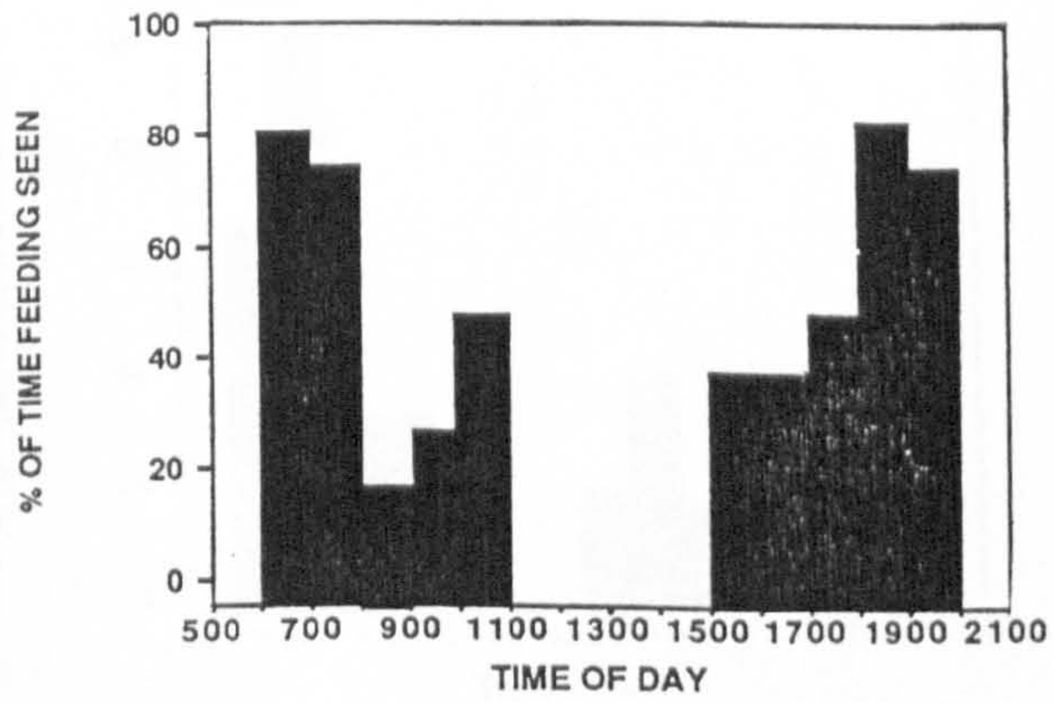


Fig 8.1.c. Females.

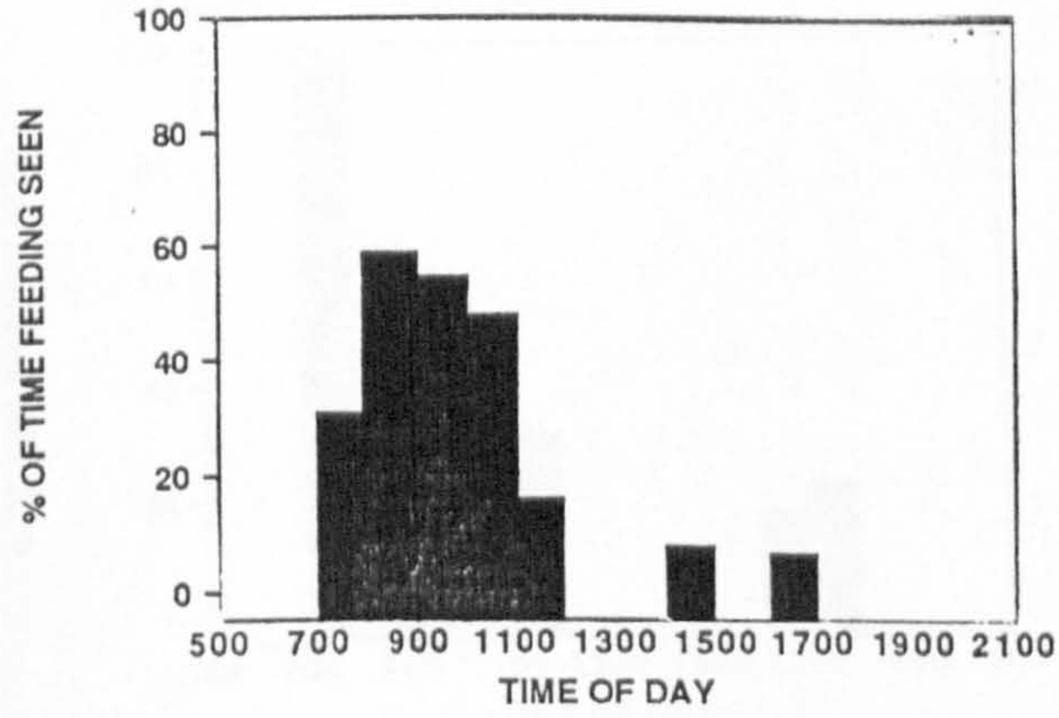


Fig 8.2. Summer. (June, July, August, September)

Fig 8.2.a. All animals.

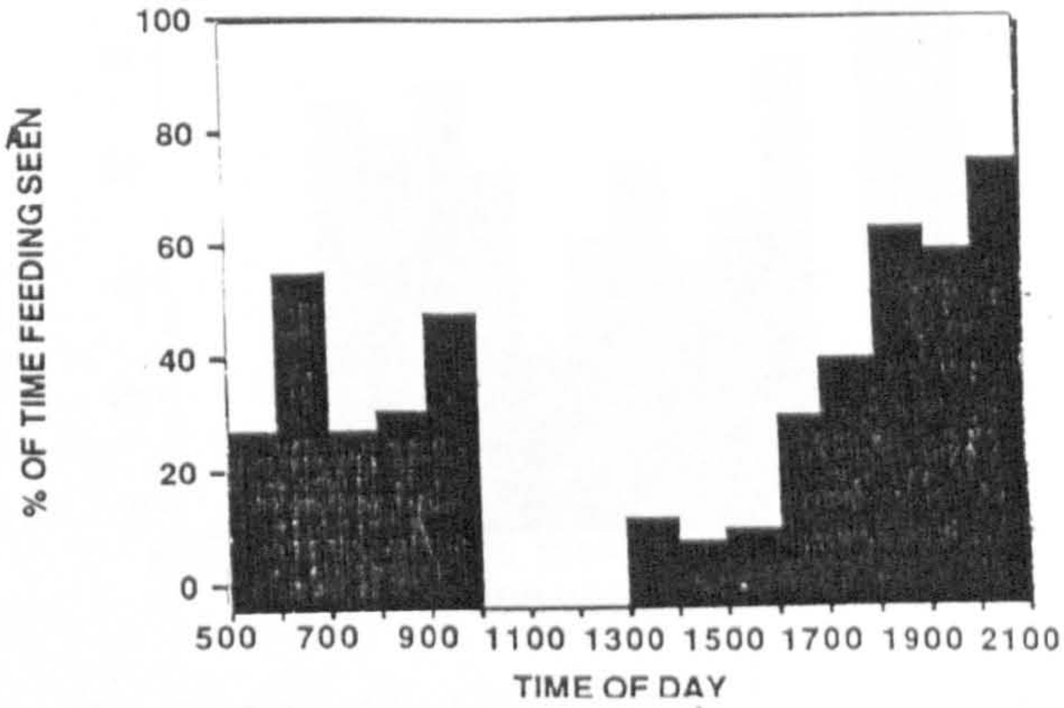


Fig 8.2.b. Males.

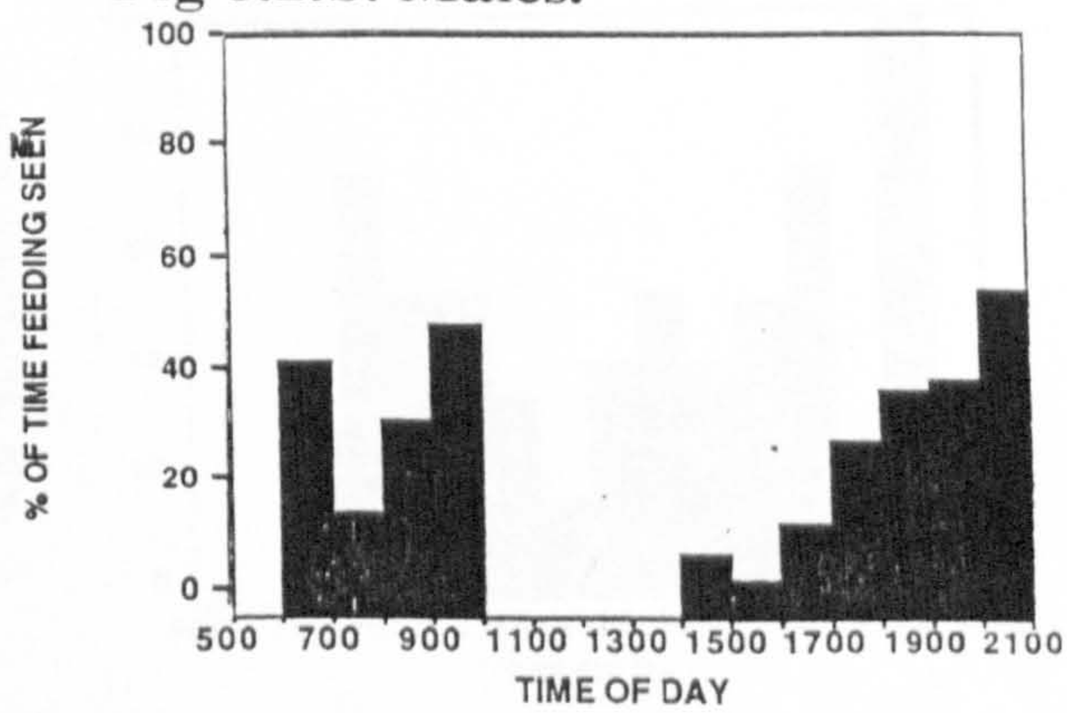
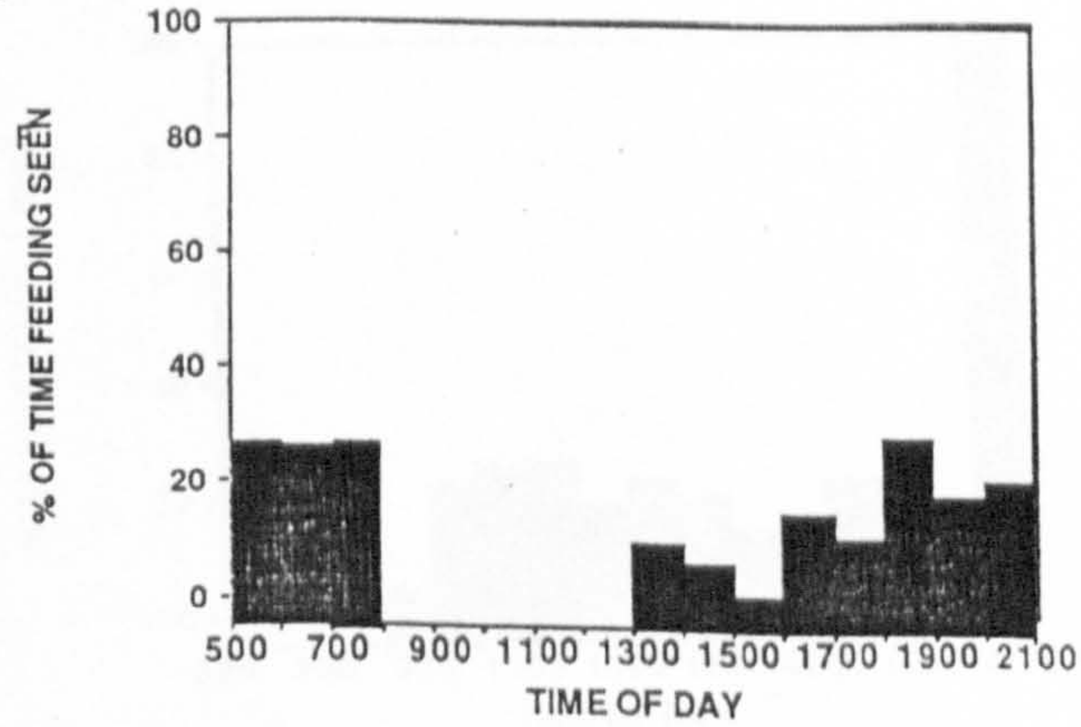


Fig 8.2.c. Females.



Percent of total observation hours that mouflon were seen feeding.

Fig 8.3. Autumn (October, November)

Fig 8.3.a. All animals.

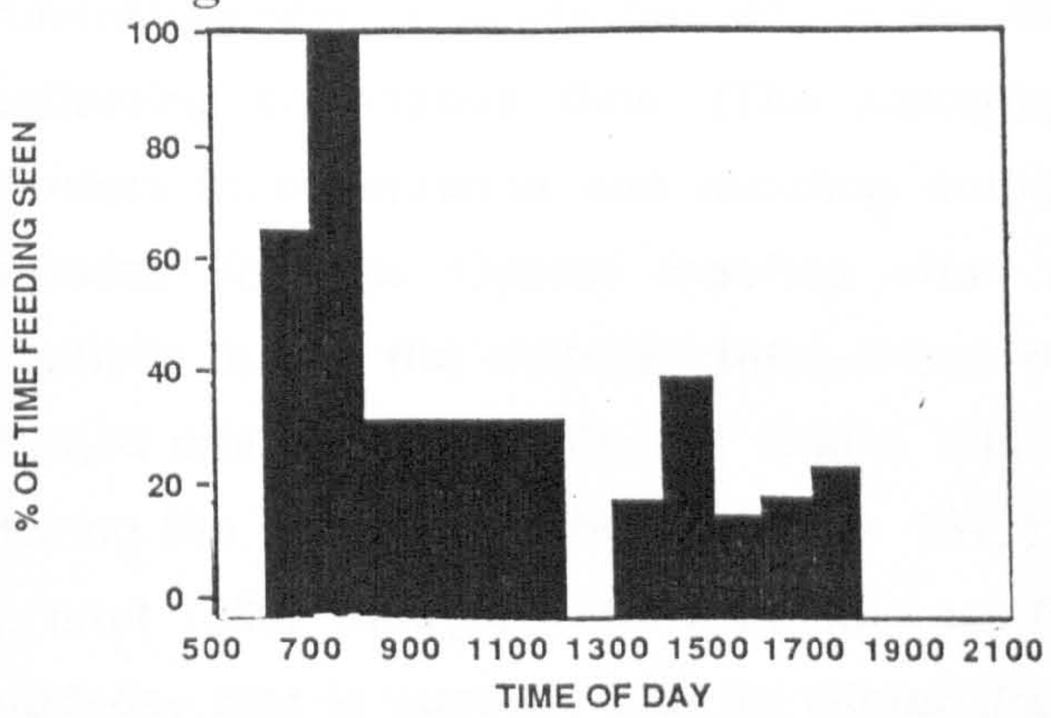


Fig 8.3.b. Males.

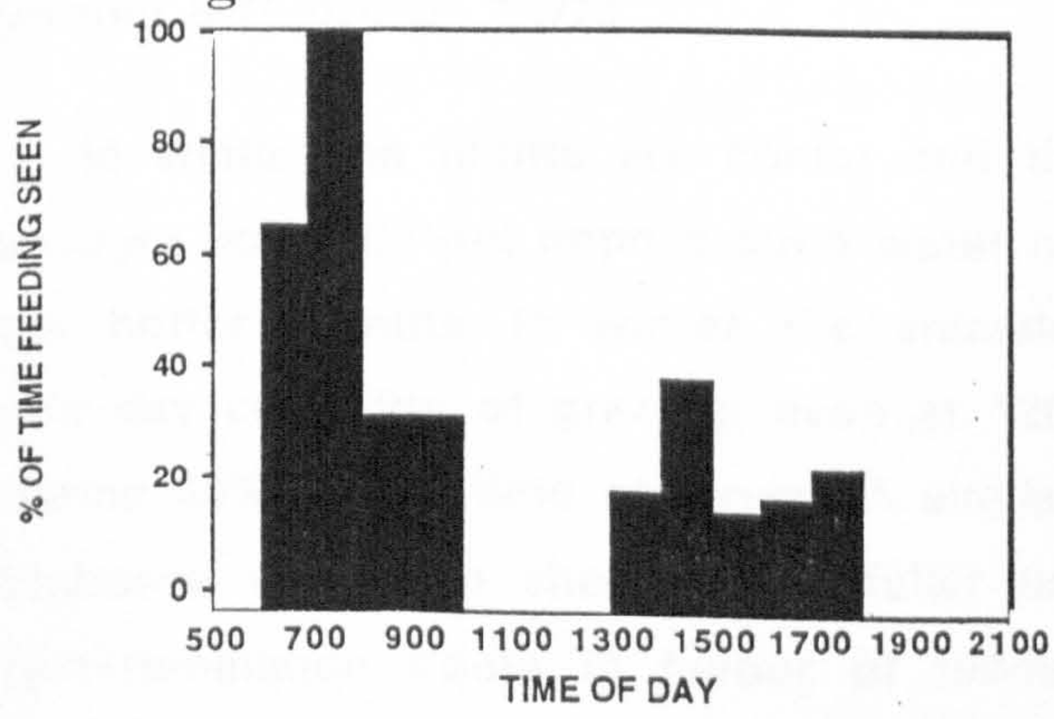


Fig 8.3.c. Females.

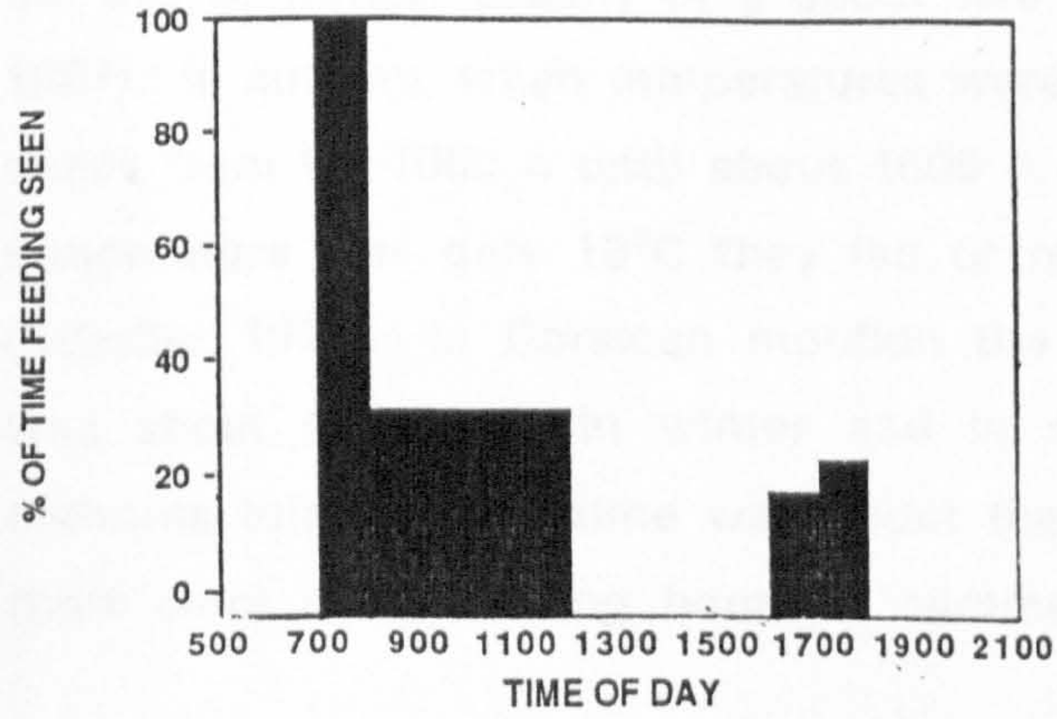


Fig 8.4. Winter (December, January, February).

Fig 8.4.a. All animals.

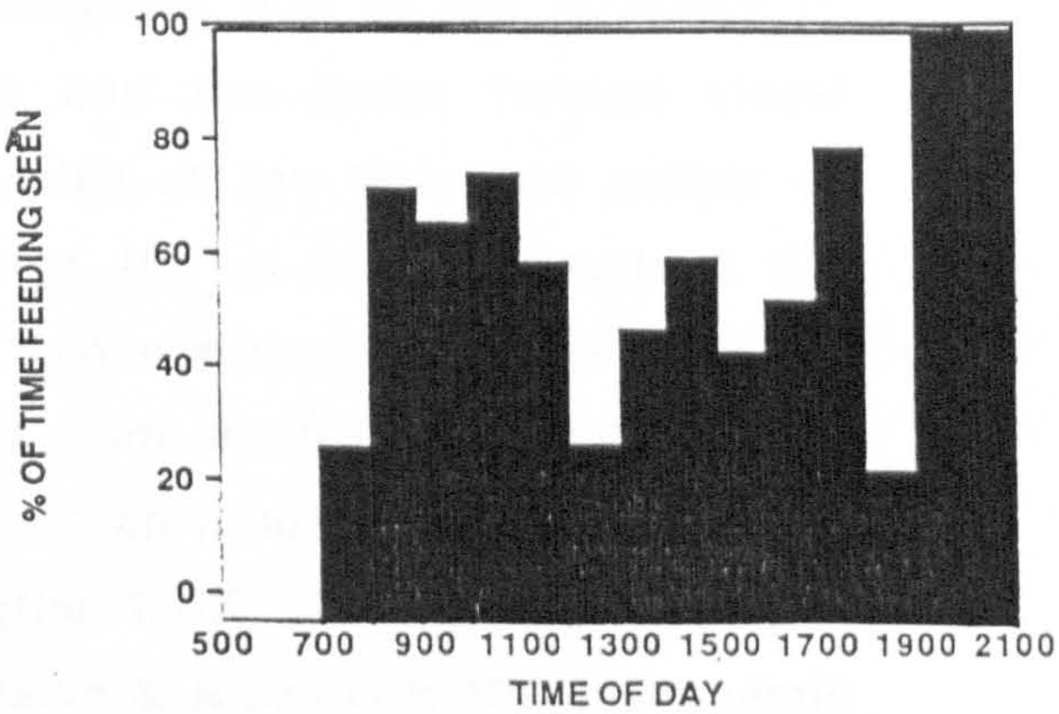


Fig 8.4.b. Males.

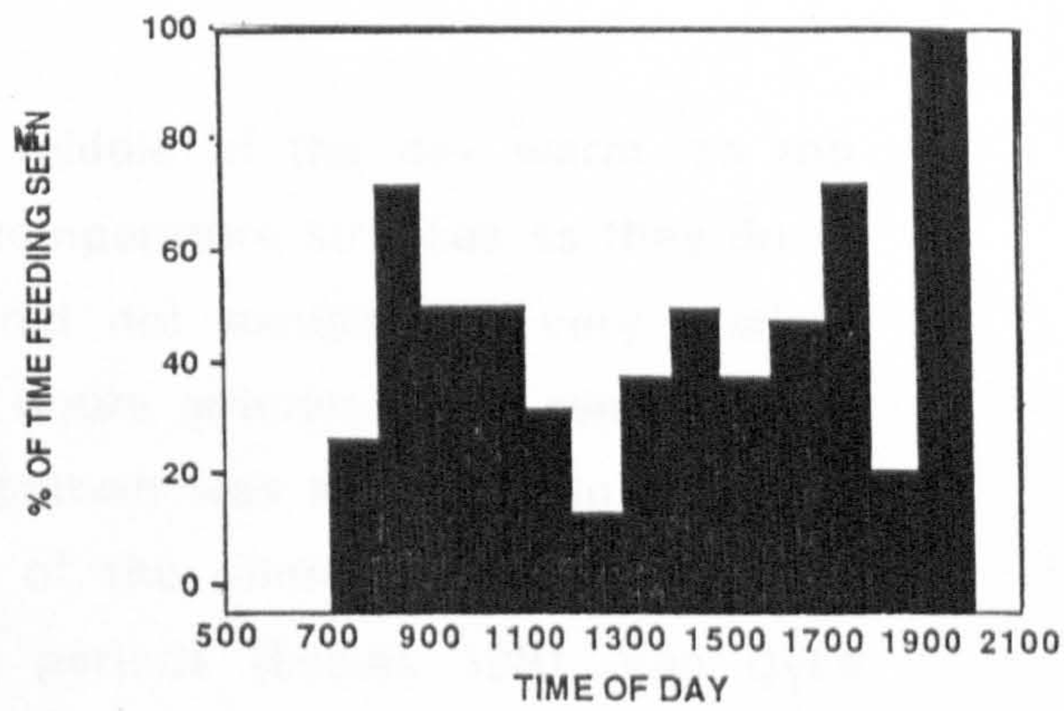
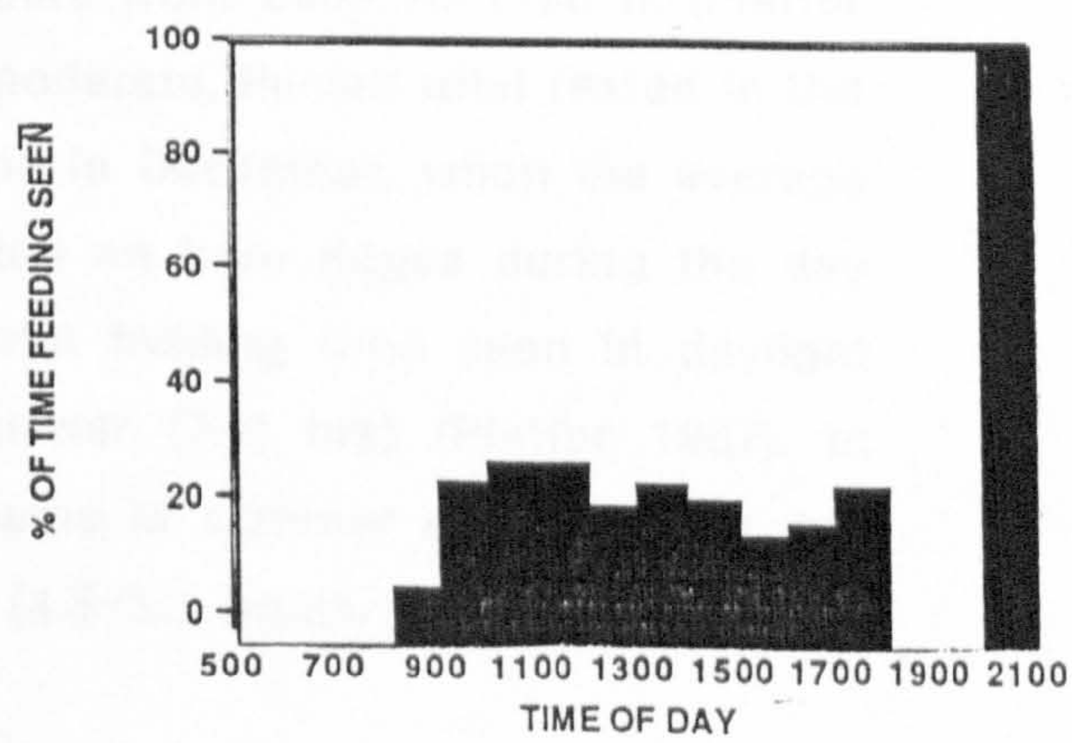


Fig 8.4.c. Females.



8.4 DISCUSSION

In spring and summer, Cyprus mouflon appeared to feed in the relatively cool mornings and late afternoons and evenings. An additional factor may have been the greater moisture content of the vegetation in the early morning, and the presence of dew. Temperature and water stress can thus be minimised by avoiding the extremes of midday. In the present study, the total number of feeding bouts (periods of feeding separated by rest/rumination periods) and ruminating/resting bouts per day were not available due to the difficulty of collecting continuous data. (The topography and the forest formed visual barriers to observation and mouflon could vanish at any time into gullies or woods). However, Cyprus mouflon often rested for up to five hours in the summer during the mid-day heat. When the temperature rose above 27-30°C Punjab urial retreated into the shade: this was from about 0730 h until 1700 h during the hottest weather (Schaller 1977). Corsican mouflon rested from 0630 h until 1500, 1600 or 1700 h in summer (Pfeffer 1967). Chamois had a longer mid-day rest in summer than in winter (Pachlatko & Nievergelt 1985). Domestic sheep started the afternoon grazing bout later if the temperature was high (Arnold & Dudzinski 1978).

In winter the nights are colder and the middle of the day warm, so the daylight hours do not impose such water or temperature stresses as they do in the hotter months. In winter the animals did not exhibit any very marked mid-day cessation of grazing: even at 1200 hours animals were seen grazing during 30% of the time observed. A similar pattern was also seen in winter in bighorns, when the sheep made fuller use of the short days by sacrificing rest-rumination bouts in favour of feeding periods (Eccles 1981, Van Dyke 1978). Corsican mouflon, too, rested for much shorter periods in the middle of the day in winter: usually only about two hours from 0900 to 1100 h. (Pfeffer 1967). In autumn, when temperatures were moderate, Punjab urial rested in the shade from 09-1000 h until about 1600 h. and in December, when the average temperature was only 18°C they fed or rested on bare ridges during the day (Schaller 1977). In Corsican mouflon the total feeding time seen in daylight was about the same in winter and in summer (7-9 hrs) (Pfeffer 1967). In bighorns total feeding time was about the same in summer and in winter, but there were more feeding bouts in summer (4.3-5.3 bouts/day) than in winter

(1.3-2.3 bouts/day) (Eccles 1981).

The mouflon were seen to graze into the hours of darkness in all four seasons. Other sheep also feed at night; Arnold & Dudzinski (1978) analysed data for 25 studies where temperature was recorded and found that the smaller the difference between daily maximum and minimum temperature, the more night grazing occurred. In 16 of the above studies where humidity was also recorded there was more night grazing when humidity during the day was high (Arnold & Dudzinski 1978). In Cyprus, with its Mediterranean climate, the summers have a low humidity but a high difference between maximum and minimum temperatures, so less night grazing in summer would be expected. However, coupled to this is the fact that there are fewer hours of darkness in summer than there are in winter, so the animals have more 'day' hours available in which to feed in summer.

8.5 SUMMARY

1. Cyprus mouflon exhibit early morning and late afternoon feeding activity peaks during the warm spring months and hot summer.
2. In winter they feed throughout the day, with only a mild drop in activity during mid-day.
3. Evening feeding bouts continue into darkness in all seasons.

CHAPTER 9
FINAL DISCUSSION AND CONCLUSIONS

9.1 Final discussion

The Mediterranean climate of Cyprus, with its hot, dry summers and mild, wet winters, allows plant growth from late autumn until the summer. Timing of food availability for mouflon in Cyprus is therefore different from the timing in the habitat of many other wild ungulates. The temperate or tropical areas in which other ungulates live are characterised by the period of highest food quality and availability occurring in the spring and summer. The availability and quality of food in Cyprus was lowest during the late summer and early autumn when little rain had fallen since April/May. Therefore, for all age/sex classes, the time of greatest potential nutritional deprivation was from August until October.

The calendar timing of the reproductive cycle for Cyprus mouflon is similar to that of other wild ungulates in the northern hemisphere outside the tropics. Mouflon are born in late April or early May, and are weaned about one month later. The rut is in the autumn, during November. Rutting males, and pregnant or lactating females are subject to higher physiological demands than animals in non-breeding condition (Kay et al. 1979). Ungulates in temperate areas must withstand cold winters when the food supply is of low quality. They tend to produce their young in the spring, when food becomes more abundant, e.g. Soay sheep (Jewell and Grubb 1974), red deer (Clutton-Brock et al. 1982). The lambs are most vulnerable in the first few weeks of their lives, so climate is critical to their survival (Sadleir 1969). The first few weeks of the lambs' life in Cyprus is the late spring, when the plants are still green and are not yet as indigestible as they become from August onwards.

In temperate areas, the spring and early summers are the times of superabundant food resources. The timing of the reproductive cycle (autumn rut, spring births) (Adsell 1964) in these temperate ungulates is the same as in the Cyprus mouflon. Decreasing daylight length is the proximate stimulus to onset of oestrus (Yeates 1949). Mouflon are thought to have been introduced from non-Mediterranean areas (see Chapter 1) to Cyprus, and they have retained the timing of the original reproductive cycle. Sheep are the most

strongly seasonal breeders among domesticated animals, and it is difficult to manipulate reproductive timing except by hormone treatment or subjecting housed animals to artificial light regimes (Owen 1976). As the timing of reproduction is controlled by the photoperiod, it seems either that there has not been strong enough selection pressure in the time during which mouflon have been on the island for a shift in the control of the timing of the breeding season, or that that it is so strongly inherent in these wild sheep that it is very difficult to alter, or a combination of both.

Reproductive and physiological requirements are affected by food availability. Pregnant female ungulates need more nutrients than non-pregnant ones. The requirements of red deer for energy and protein are slight during the first two-thirds of the gestation period, but during the last third they increase logarithmically (Clutton-Brock et al. 1982). Soay sheep are also thought to follow this pattern (Boyd and Jewell 1974). Similarly, in domestic sheep the requirements of ewes are much higher in the last two months of their gestation than in the first three months (Owen 1976). The costs of lactation in red deer are even higher than those of pregnancy, and peak in the 4th-6th week after birth (Clutton-Brock et al. 1982). Domestic ewes in peak lactation require three times those of dry ewes and food intake is 30-50% higher during lactation than during late pregnancy (Owen 1976). The costs for female mouflon are probably similar in their timing and magnitude. Gestation time for Soay sheep, domestic sheep, and Corsican mouflon is about 150 days (Adsell 1964, Jewell and Grubb 1974, Krumbiegel 1954, Mottl 1960), and seemed to be the same for the Cyprus mouflon (personal observations and Forestry Dept. of Cyprus information). These patterns of reproductive energy demands suggest that energy and protein requirements of pregnant mouflon would start to rise in January (two-thirds of the way through gestation). There was abundant, digestible food available in the Paphos forest during this period of expected high demands. The problems of poor quality food resources encountered by temperate climate sheep during January and February were not present in Cyprus. The mouflon should have no difficulty in obtaining abundant digestible food at this time.

When the lambs were about one month old, there was still moderately high quality food available. (Chapter 3) During the weaning of the young, the grasses matured, flowered, and died, and many of the other plants became less digestible (Chapter 3). By August, the young as well as the adult mouflon had

to feed on the dried grass litter, the remaining forbs, and the shoots of shrubs and trees.

Young mouflon probably need a higher quality diet than the adults, because of growth requirements and their smaller body size. Young red deer and young African ungulates were thought to require higher quality food than adults (Clutton-Brock and Harvey 1982, Bell 1971) because of their smaller body size compared with the adults. Interspecific differences between ungulates of differing body size has been shown to lead to differences in nutritional requirements; smaller animals needing higher quality foods (Jarman 1974). However, smaller animals can survive better on short swards than larger animals (Illius and Gordon 1987). Having smaller mouths, the young should be able to select small, nutritious plant parts such as shoots, buds and flowers more easily than the broader-muzzled adults (Janis and Ehrhardt, 1988). Domestic lambs ate more than yearlings on a sparse pasture in a study by Allden and Whittaker (1970), and this was thought to be due to their smaller mouths. During the summer young mouflon may therefore be able to take advantage of the buds and fruits of broadleaved trees, shrubs, and green forb parts that were unavailable to the adults.

Male ruminants, especially mature, reproductively active male sheep, and males of many deer species, have their highest energy costs during the rut. Many lose body condition during the rut, because the time that would otherwise be spent grazing is taken up with activities such as following oestrus females and discouraging competitors. Bighorn, Dalls and Stones sheep (Geist 1971), Soay sheep (Grubb and Jewell 1974) and red deer (Clutton-Brock et al. 1982) all lose condition in the rut. There appears to be little opportunity to recover condition after the rut in these temperate climate animals as the quality of the food resources available is so low (Grubb 1974b). In addition to the pronounced loss of condition among males, there is often a high post-rut mortality in temperate climates (Clutton-Brock 1982, Grubb 1974b).

Immediately following the rut in Cyprus, unlike in temperate habitats, the vegetation begins to grow, providing young, fresh, easily digestible material, especially forbs and grasses. Thus the nutritional crisis experienced by other wild sheep does not occur in winter for Cyprus mouflon. In addition, the winter temperatures were milder than those in temperate climates, snowfall being light and infrequent and rarely lying for more than a day or two in the Paphos

forest during the study period of 1984-86. The lower critical temperature for sheep was calculated to be -20°C (Alexander 1974). There was not, therefore, a great danger of heat loss by the animals during the mild Cyprus winters. The post rut period in Cyprus seems not to be the worst time of year for male mouflon. The period from August until October was the time of lowest food quality and availability, which meant that the males had to maintain or at least to lose as little condition as possible in preparation for the autumn rut during November.

It is not known whether the appetite of the Cyprus mouflon was depressed during any part of the year. Appetite is suppressed among red deer during the rut (Clutton-Brock et al. 1982) and for white tailed deer, reindeer, red deer, and moose during the winter (Clutton-Brock et al. 1982). Domestic and feral sheep appetite is also depressed in winter (Gordon 1964, Tarttelin 1968), and differs between breeds in the degree of this depression. For instance, in winter, Soay sheep ate less than 30% of their summer intake, whilst in crossbred Suffolk x Finn x Dorset the winter depression of intake was only to 85% of the summer amounts (Blaxter and Gill 1979). Perhaps animals closer to the wild sheep retain a higher degree of appetite suppression in winter, or, conversely, sheep that have been bred to cope with harsher winters, such as the Soays of St. Kilda have a more marked appetite loss in the winter. Appetite loss is believed, in red deer, to be controlled by daylength (reviewed by Clutton-Brock et al. 1982). According to Clutton-Brock et al. (1982) the loss of appetite during winter "presumably helps to reduce the energetic costs of feeding in situations where the quality or quantity of food does not allow individuals to cover their daily requirements". The animals' metabolic rate is lowered, and there is a lower rate of food intake during winter when these temperate animals lose weight (Moen 1973). It would be interesting to find out if the Cyprus mouflon had a drop in appetite during winter. It would not appear to be an adaptive system in a Mediterranean environment, as the winter is the period of high plant quality.

The best descriptor of plant acceptability is digestibility (Blaxter et al. 1961, Elfyn Hughes et al. 1964, Minson et al. 1964, Hodgson 1968) plus availability (Arnold and Dudzinski 1967, Rawes and Welch 1969, Colquhoun 1971). Digestibility is often linked with the crude protein content of a forage. Choice and consumption of different forage plants was strongly affected by season (Chapters 4 and 6). Season affected both the availability and the quality of different plant groups (Chapters 2 and 3). During the wet season, the mouflon

ate the mainly highly digestible and proteinaceous grasses, forbs and non-graminaceous monocots. High proportions of these classes of food were in fact eaten all year. Broadleaved trees made up a larger proportion of the food eaten during the summer than during the wet season (up to 25% of the diet was broadleaved trees in some areas). Broadleaved trees contained the highest protein content of all plant types available to the mouflon during the summer. The protein content and the digestibility of the plants of the herb layer, especially the grasses and monocots, fell during summer. Ungulates typically select diets higher in protein than the average levels in the foliage available to them (Price 1978). Grass-feeding African savanna ungulates supplement their diet with woody browse in the dry season when nitrogen levels in the grasses fall below maintainance level (Field 1976). Mouflon probably ate more broadleaved trees during the summer to make up the protein deficit that would have occurred if they had continued to eat only grasses, forbs and monocots. Broadleaves were also more digestible during the summer than during the winter. Woody browse in Mediterranean areas tend to grow from April until July, unlike the plants of the herb layer, which start growth with the onset of the autumn rains (Longhurst et al. 1979) which occur in November in Cyprus. The digestibility and protein content of growing plants is usually higher than in senescent or dead ones. In addition, consumption of protein along with food of low quality enhances digestibility of that food (Hobbs et al. 1981, McCullough 1979). Dry matter digestibility of grasses declines dramatically with the onset of flowering, as leaf protein levels decline, and fibre and tannin contents rise (Raymond 1969), which, in Cyprus, occurs around April-May.

Among sheep we probably find some of the most drought and heat-resistant of any medium to large-size animal, outdone only by the camel and some wild antelopes and gazelles (Schmidt-Nielsen 1964), and Bedouin goats (Brosh et al. 1986). A sheep fed little at high ambient temperatures produces less internal heat and therefore does not need to lose so much heat by water evapouration (Schmidt-Nielsen 1964). Hair sheep have been found to have long loops of Henle, to produce highly concentrated urine, high water reabsorption both in the colon and in the kidney, a low water turnover (180ml per 0.82kg per 24hrs), and a low sweating:respiratory ratio (evaporative cooling ratio) of 0.2 (Macfarlane 1968). Mouflon in Cyprus have ample shade in which to avoid the highest temperatures of summer in the environment of the Paphos

forest, unlike the steppe/open habitats of the wild sheep on the mainland. In addition, if they are like the hair sheep outlined above, it seems that they will be able to cope fairly well with the low food quality in summer by a combination of behavioural adaptions and forage choice, even if water is in short supply. Herbivores excrete less nitrogen in their faeces when their food is low in protein (Schmidt-Nielsen 1979). In ruminants, urea can be recycled when protein is in short supply in the forage (Houpt 1959). Mouflon diet quality from late summer until early autumn was poor, confirmed by nitrogen analysis of the mouflon faeces (see chapter 5). From August until October, mouflon were probably close to, or below, the threshold of crude protein intake required for nitrogen metabolism in sheep, when they would have lost body condition (body fat reserves and muscle mass). The timing of this must be particularly important, as outlined above, for both the lambs born earlier in the same year, and for the males. The highest quality diet was ingested from February until May, and in one valley up until June (Fig 5.2).

The consumption of certain shrubs by mouflon in the winter and spring contrasted with their absence in the diet in the dry season. This was, as has been outlined in the discussion in Chapter 6, possibly linked with the secondary plant compounds in many of these Mediterranean plants (such as *Cistus creticus, Lithodora hispidula* and *Teucrium kotschyanum*), as well as seasonal fluctuations in digestibility and protein. During the late summer, the digestibility and crude protein content of *Teucrium* were below the levels necessary for ruminants. An opportunity for further study here would be the examination of the relationships between the seasonality of antiherbivore compounds such as alkaloids, condensed tannins, and total phenolics and the consumption of plants containing these compounds. Bryant and Kuropat (1980) among others, have suggested that some herbivores base their feeding preferences not on maximising nutrition, but on avoiding toxins and digestibility inhibitors. The two most strongly avoided plants, *Pinus brutia* and *Rubus sanctus*, were common in the environment, and may well have been avoided because of antiherbivore chemical content.

Male mouflon were in smaller groups in the summer than in the wet season (Chapter 7). Buffalo in the Serengeti also vary their group size annually, aggregating in smaller groups in the dry season (about 100 animals) than in the wet season (about 500) (Sinclair 1974). This was thought by Sinclair to be because of the decreasing size of patches of habitat that carried appropriate

food. Other East African ungulates with 'open membership' groups e.g. Cokes hartebeest *Alcelaphus buselaphus* and Thompsons' gazelle *Gazella thompsoni* display a similar fall in group size from their wet-season occupation of the plains to dry season use of woodlands. Grants gazelle *G. granti* also reduce group size in closed habitats (Walther 1972). Zebra *Equus burchelli* also showed this at the level of the feeding aggregation but not at the level of the family group, which is of fixed membership and size) (Jarman and Jarman 1979). Topi *Damaliscus korrigum* were in big herds in open habitats (where food items were abundant and evenly dispersed) and in small herds in woodland where not only was food less abundant or less evenly dispersed, but visibility was also restricted (Duncan 1975). The phenomenon is also common in some deer species, e.g. chital *Axis axis* (Mishra 1982), white tailed deer (Hirth 1977), and elk (Franklin et al. 1975). See Chapter 7 for other species displaying the same behaviour. Therefore it seems likely that male mouflon tend to be in smaller groups in the dry season because forage is more scattered.

Males were consistently in bigger groups than females (Chapter 7). Males have a larger body size than females: males weigh 50-55kg, females 40-45kg (Athalassa Research station information, Cyprus). Intersexual differences in feeding ecology occur in other sexually dimorphic species, red deer for instance (Clutton-Brock et al. 1982, Staines et al. 1982) or bighorn sheep Geist 1971). Larger species were also often in bigger groups than smaller ones in Jarmans' comparative study of different antelope species in Africa (Jarman 1974). Larger animals with larger mouthparts are forced to be less selective than smaller animals, which has been discussed for the young and adult mouflon (see above). Male mouflon, too, may be less selective than the females. The combination of smaller body size and smaller mouthparts could be one factor accounting for the smaller group sizes of females. A more selective animal finds it difficult to forage in a large group, the food items being distributed in a more scattered way than lower quality, more abundant foods eaten by less selective animals. Individuals of smaller species are more likely to depend on refuges or cryptic colouration to avoid detection by predators, while individuals of larger species are more likely to depend on self defence, group defence, group alertness and anonymity within a group (Jarman and Jarman 1979). This may be another reason why the smaller female mouflon were in smaller, less conspicuous groups than the males.

Mouflon seem to have adapted behaviourally to living in the forests of

Cyprus. They were in smaller groups than their congeners elsewhere that live in the open. They avoided the high summer temperatures by adjusting their daily feeding times with the seasons. They also adjusted their diet with the seasons, appearing to take advantage of broadleaved trees to supplement their diet during the dry season when there was less digestible, proteinaceous grass available. They have not, however, adjusted the timing of their reproductive cycle so that the young are born when food is becoming more abundant, unlike most temperate and tropical ungulates. However, they seem to have little difficulty in surviving under these unusual rainfall conditions.

9.2 Summary

The most powerful influence on the feeding ecology of mouflon appeared to be the pattern of winter rains, which allowed the vegetation to grow during the winter and early spring. Plants of the herb layer (grasses, forbs and non-graminaceous monocots) were highly digestible and had a high crude protein content during the wet season. Woody browse plants had their highest digestibilities and protein contents later in the year, during the late spring and early summer.

Mouflon therefore had access to high quality food during the winter, in contrast to the habitats of most other wild ungulates, where food quality is highest during the spring and summer months. In the Mediterranean summer, the food supply became less abundant, less digestible, less proteinaceous and contained less phosphorus than during the wet season.

During the time when the food supply was improving, the daylength was decreasing, which is the stimulus for ovulation in sheep, leading to spring births. In temperate and tropical climates spring births occur as the food supply is increasing, but in the Cyprus mouflon it meant that the young had to cope with reduced quality food soon after they were weaned. However, the males had the opportunity to regain condition after the rut in the autumn, whereas those ungulates in non-Mediterranean climates are faced with poor quality food from the end of the rut until the following spring.

The diet consumed by the Cyprus mouflon consisted largely of grasses, forbs and non-graminaceous monocots all year. However, during the summer, a higher proportion of broadleaved trees were eaten than during the wet season,

and a lower proportion of grasses, probably because the broadleaved trees contained much more crude protein during the summer than the grasses, and because the trees were also more digestible than grasses during summer. In addition there was less grass available during the summer. Forbs remained fairly digestible and proteinaceous during the summer, and were eaten in slightly larger proportions than during the wet season.

A selectivity index was calculated for the different foods consumed by mouflon. and these results ranked. Non-graminaceous monocots were ranked highly all year, and grasses and forbs were ranked middle to low. The two least preferred foods were *Pinus brutia* and *Rubus sanctus*, and these ranked lowest of all.

Examination of the diet quality of the mouflon by nitrogen analysis of the faeces confirmed that the late summer and early autumn were the worst time of the year, nutritionally speaking. It was found that the estimated crude protein intake during August, September and October was close to, or in some cases, below the maintainance level for some ruminants. Therefore at this time of the year mouflon may have lost body condition.

When the group sizes of the mouflon were investigated, it was clear that their social organisation was similar to most other wild sheep studied in that they formed single-sex groups during most of the year, and mixed-sex groups during the rut. However, they were in smaller groups than wild sheep living in open habitats, probably due to the effects of forest dwelling. Males were in smaller groups in the dry season than in the wet season, and this was thought to be because of the differences in forage availability and dispersion, food being in fairly large patches of high quality during winter, and in a more evenly scattered distribution in the summer. No significant seasonal differences in group size between females occurred. Males were in consistently larger groups than females, which could have been due to different anti-predator behaviour patterns caused by the differences in body size between the sexes, and to the different nutritional requirements of animals of different body size.

Mouflon avoided activity during the high temperatures encountered in the middle of the day in the hot season, and were seen to feed during the early morning and evening. During the winter they fed during most of the hours of daylight.

Further study suggested was an examination of the seasonality of the antiherbivore chemistry of the plants of the Paphos Forest and its effect on the diet of mouflon. A knowledge of the population size and its rate of increase would also be of use in the management of the forests for this endangered species. Relationships between energy intake, appetite, body condition and season would also be informative, as the degree of loss of body condition during the dry season could be quantified, and compared to that which occurs in temperate climate sheep.

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Appendix 1 THE BOTANICAL SURVEY.

Mean percent cover of each plant species in each valley by month. Ayia, Pia, Vroisha, Limnitis and Aymerc (Ayios Mercurios) are the names of the valleys surveyed. N=No. of plots in which the species was found each month.

January

Species	N	AYIA	PIA	VROISHA
Acer obtusifolium	2.0	10.50	_	_
Anemone coronaria	2.0	_	6.55	_
Arisarum vulgare	6.0	_	3.10	1.92
Asparagus acutifolius	3.0	0.20	_	1.30
Asphodelus aestivus	13.0	2.75	0.98	3.67
Astragalus lusitanicus	1.0	_	2.00	_
Avena ludoviciana	2.0	_	6.92	_
Calendula arvensis	1.0	_	_	2.00
Centaurea aegialophila	1.0	0.20	_	_
Cistus creticus	15.0	9.53	19.29	11.29
Cistus salviifolius	2.0	4.00	7.30	_
Large composite sp.	5.0	_	1.00	1.40
Crataegus sp.	4.0	_	0.10	0.20
Cyclamen cyprium	2.0	1.80	_	_
Dactylis glomerata	5.0	_	14.33	1.80
Echinops spinosissiumus	6.0	0.90	_	0.40
Equisetum sp.	1.0	_	_	3.80
Euphorbia sp.	1.0	_	_	0.20
Gallium aparine	12.0	1.37	0.90	1.04
Geranium purpureum	9.0	0.57	0.50	0.33
Gladiolus triphyllus	3.0	_	_	0.67
Grass shoots	15.0	7.73	25.07	13.87
Hypericum sp.	1.0	_	_	0.50
Inula viscosa	4.0	_	_	2.95
Lathyrus aphaca	11.0	0.15	0.25	0.52
Lithodora hispidula	3.0	_	1.00	6.05
Lonicera etrusca	1.0	0.20	_	_
Lotus sp.	6.0	_	4.98	5.15
Melica minuta	5.0	1.17	_	0.10
Mentha longifolia	2.0	_	_	3.60
Muscari comosum	1.0	_	1.90	_
Nerium oleander	1.0	3.50	_	_
Olea europea	1.0	_	4.00	_
Orchids	7.0	0.25	0.20	0.30
Origanum dubium	3.0	_	10.00	2.20
Orlaya daucoides	1.0	2.50	_	_
Ornithopus compressus	3.0	_	4.71	_
Pinus brutia	3.0	_	2.00	4.00
Poa bulbosa	1.0	0.20	_	_
Poterium verrucosum	4.0	_	_	0.85
Pteridium aquilinum	1.0	_	_	0.50
Quercus alnifolia	3.0	3.65	_	19.70
Ranunculus ficaria	2.0	_	0.50	1.70
Ranunculus sp.	9.0	0.20	5.58	0.90
Rhamnus alaternus	2.0	_	1.33	_
Romulea tempskyana	1.0	_	0.40	_
Rubia tenuifolia	5.0	0.83	_	1.30
Rubus sanctus	3.0	2.30	_	15.10

Rumex sp.	2.0	–	–	1.10
Salvia verbenaca	2.0	–	–	0.50
Sarcopoterium spinosum	2.0	–	13.10	–
Scilla autumnalis	1.0	–	0.30	–
Senecio vulgaris	5.0	–	0.55	0.37
Silenevulgaris	1.0	–	–	1.10
Small composite sp.	11.0	0.43	1.63	2.96
Smilax aspera	1.0	1.50	–	–
Stellaria media	1.0	–	–	0.60
Taraxacum sp.	9.0	0.70	2.70	3.67
Teucrium kotschyanum	4.0	1.27	–	1.30
Thymus integer	2.0	–	–	3.65
Trifolium sp.	17.0	0.23	7.80	23.81
Umbellifer sp.	9.0	–	1.10	3.09
Urginea maritima	2.0	–	0.13	–
Vicia cassia	10.0	0.20	0.13	0.43
Vicia pubescens	4.0	0.15	–	1.70

FEBRUARY

Species	N	AYIA	PIA	VROISHA
Acer obtusifolium	2.0	10.70	_	_
Anemone coronaria	4.0	_	5.43	0.90
Arabis sp.	1.0	0.40	_	_
Arisarum vulgare	7.0	_	0.95	1.84
Asparagus acutifolius	4.0	0.20	0.50	1.00
Asphodelus aestivus	12.0	3.25	1.01	4.42
Astragalus lusitanicus	1.0	_	2.00	_
Avena ludoviciana	1.0	_	5.00	_
Calendula arvensis	2.0	_	_	2.10
Centaurea aegialophila	2.0	0.30	_	0.10
Cistus creticus	14.0	11.47	18.48	11.54
Cistus salviifolius	3.0	5.50	5.36	_
Large composite sp.	4.0	_	_	1.93
Crataegus sp.	3.0	_	_	0.33
Cyclamen cyprium	3.0	1.47	_	_
Dactylis glomerata	7.0	_	11.25	1.02
Echinops spinosissiumus	4.0	0.20	_	0.23
Equisetum sp.	1.0	_	_	2.00
Ficus carica	1.0	_	_	3.80
Gagea sp.	3.0	_	0.32	0.10
Gallium aparine	13.0	1.20	0.38	1.59
Geranium purpureum	9.0	0.60	0.32	0.49
Grass shoots	16.0	8.90	24.80	15.66
Inula viscosa	4.0	_	_	2.23
Lathyrus aphaca	6.0	0.30	0.25	0.33
Lily sp.	1.0	_	_	3.10
Lithodora hispidula	3.0	_	2.00	3.00
Lonicera etrusca	1.0	0.10	_	_
Lotus sp.	8.0	_	4.13	2.85
Medicago sp.	3.0	_	1.43	6.25
Melica minuta	4.0	1.30	_	1.78
Mentha longifolia	3.0	0.40	_	2.40
Nerium oleander	1.0	0.50	_	_
Olea europea	1.0	_	4.00	_
Orchids	7.0	2.45	0.20	0.23
Origanum dubium	3.0	_	_	1.88
Orlaya daucoides	1.0	3.90	_	_
Ornithopus compressus	9.0	_	4.28	0.45
Pinus brutia	4.0	_	1.50	2.87
Poterium verrucosum	4.0	_	0.30	0.80
Prasium majus	2.0	_	0.60	_
Pteridium aquilinum	1.0	_	_	0.50
Quercus alnifolia	3.0	4.25	_	20.50
Ranunculus ficaria	3.0	_	_	0.50
Ranunculus sp.	9.0	0.20	3.42	0.73
Rhamnus alaternus	1.0	_	1.43	_
Romulea tempskyana	1.0	_	2.20	_
Rubia tenuifolia	6.0	0.73	0.10	6.65
Rubus sanctus	3.0	2.45	_	4.10
Rumex sp.	2.0	_	_	0.65
Salvia verbenaca	2.0	_	_	0.35
Sarcopoterium spinosum	3.0	_	11.93	_
Senecio vulgaris	5.0	_	0.10	0.70
Silene vulgaris	1.0	_	_	0.90
Small composite sp.	15.0	0.47	2.47	1.54

Smilax aspera	3.0	0.80	_	0.10
Taraxacum sp.	11.0	0.55	1.99	2.93
Teucrium kotschyanum	4.0	1.33	_	1.60
Thymus integer	3.0	_	_	2.37
Trifolium sp.	14.0	0.35	8.53	23.19
Umbellifer sp.	10.0	_	0.73	2.09
Urginea maritima	1.0	_	0.10	_
Vicia cassia	5.0	0.10	0.27	0.30
Vicia pubescens	8.0	0.10	_	0.69

MARCH

Species	N	AYIA	PIA	VROISHA
Acer obtusifolium	2.0	11.60	_	_
Anagallis arvensis	9.0	0.30	0.20	0.81
Anchusa sp.	1.0	_	_	0.20
Anemone coronaria	3.0	_	5.00	_
Arisarum vulgare	10.0	0.10	1.50	1.49
Asparagus acutifolius	3.0	0.20	_	0.40
Asphodelus aestivus	16.0	4.45	1.83	4.10
Astragalus lusitanicus	1.0	_	2.00	_
Avena ludoviciana	1.0	_	_	0.10
Biscutella didyma	3.0	_	_	0.20
Bromus sp.	2.0	_	0.50	0.10
Calendula arvensis	7.0	_	_	1.49
Centaurea aegialophila	1.0	0.50	_	_
Cistus creticus	16.0	12.80	17.80	12.52
Cistus salviifolius	2.0	_	6.07	_
Large composite sp.	4.0	_	_	1.58
Crataegus sp.	3.0	_	_	0.47
Cyclamen cyprium	4.0	1.05	_	_
Dactylis glomerata	7.0	_	9.34	2.50
Dicot shoots	1.0	_	_	0.10
Echinops spinosissiumus	5.0	0.60	_	0.66
Equisetum sp.	1.0	_	_	1.85
Euphorbia sp.	1.0	_	_	0.10
Gagea sp.	4.0	1.50	_	0.47
Gallium aparine	17.0	0.53	0.54	1.59
Geranium purpureum	10.0	0.25	0.30	0.42
Gladiolus triphyllus	7.0	_	_	0.36
Grass shoots	20.0	9.27	23.50	13.94
Hedera helix	2.0	0.10	_	0.50
Hypericum sp.	2.0	_	_	0.10
Inula viscosa	3.0	_	_	2.95
Lathyrus aphaca	12.0	0.15	0.15	0.66
Lithodora hispidula	5.0	_	2.10	2.61
Lonicera etrusca	1.0	0.50	_	_
Lotus sp.	11.0	_	3.56	2.33
Medicago sp.	12.0	1.25	4.24	1.77
Melica minuta	5.0	1.30	_	0.90
Mentha longifolia	3.0	0.60	_	2.48
Micromeria nervosa	1.0	_	_	2.25
Muscari comosum	4.0	_	0.32	0.83
Nerium oleander	1.0	4.00	_	_
Olea europea	1.0	_	6.00	_
Orchids	10.0	0.85	0.20	0.18
Origanum dubium	4.0	_	_	1.35
Orlaya daucoides	1.0	6.10	_	_
Ornithogallum sp.	2.0	_	_	0.90
Ornithopus compressus	3.0	_	20.71	0.20
Pinus brutia	4.0	_	2.00	0.85
Pistachia terebinthus	1.0	_	_	0.11
Poa bulbosa	2.0	0.65	_	_
Poterium verrucosum	4.0	_	_	0.53
Prasium majus	2.0	_	0.60	_
Pteridium aquilinum	5.0	2.30	_	1.50
Quercus alnifolia	4.0	2.93	_	20.00
Ranunculus ficaria	1.0	_	_	1.20

Ranunculus sp.	9.0	0.30	2.41	0.87
Rhamnus alaternus	1.0	–	1.43	–
Rubia tenuifolia	6.0	1.63	–	0.93
Rubus sanctus	3.0	2.30	–	15.30
Rumex sp.	2.0	–	–	0.35
Salvia verbenaca	2.0	–	–	0.80
Sarcopoterium spinosum	3.0	–	13.00	–
Senecio vulgaris	6.0	–	0.10	0.70
Silene vulgaris	1.0	–	–	0.70
Small composite sp.	16.0	0.90	2.41	1.83
Smilax aspera	2.0	0.75	–	–
Stellaria media	4.0	1.60	–	0.47
Tamus communis	1.0	0.20	–	–
Taraxacum sp.	14.0	0.55	2.78	2.39
Teucrium kotschyanum	4.0	1.33	–	2.50
Thymus integer	2.0	–	–	3.80
Trifolium sp.	16.0	0.10	4.09	13.86
Trifolium stellatum	1.0	–	–	10.85
Umbellifer sp.	14.0	0.20	0.23	1.93
Urginea maritima	3.0	–	0.10	0.32
Vicia cassia	11.0	0.20	0.20	0.77
Vicia pubescens	7.0	–	–	0.72
Viola sp.	2.0	0.10	–	0.20

APRIL

Species	N	AYIA	PIA	VROISHA
Acer obtusifolium	3.0	7.63	_	_
Aegilops sp.	3.0	_	0.20	0.10
Aira elegans	6.0	0.28	_	1.13
Allium sp.	9.0	0.95	1.65	5.92
Anagallis arvensis	8.0	0.15	0.35	0.58
Anchusa sp.	1.0	_	_	0.20
Arabis sp.	1.0	0.30	_	_
Arisarum vulgare	4.0	0.10	0.10	1.75
Asparagus acutifolius	3.0	0.18	_	1.00
Asphodelus aestivus	16.0	4.10	1.78	4.36
Astragalus lusitanicus	3.0	0.40	1.50	0.20
Avena ludoviciana	9.0	0.10	4.37	0.49
Biscutella didyma	2.0	_	_	0.35
Briza maxima	6.0	0.10	0.26	0.93
Bromus sp.	43.0	3.43	6.66	4.81
Calendula arvensis	4.0	5.40	_	0.88
Centaurea aegialophila	1.0	1.10	_	_
Cistus creticus	17.0	10.80	19.02	10.68
Cistus ladanifer	1.0	4.00	_	_
Cistus salviifolius	7.0	6.18	4.36	3.00
Large composite sp.	3.0	_	_	1.98
Crataegus sp.	3.0	_	_	0.25
Cyclamen cyprium	5.0	1.71	_	0.10
Cynosurus echinatus	7.0	2.23	0.10	1.17
Dactylis glomerata	6.0	_	9.83	0.67
Echinops spinosissiumus	7.0	0.70	0.50	0.97
Equisetum sp.	1.0	_	_	2.00
Gallium aparine	17.0	0.88	5.03	0.93
Geranium purpureum	7.0	0.78	0.70	0.20
Gladiolus triphyllus	3.0	_	_	0.10
Grass	1.0	1.10	_	_
Grass shoots	3.0	_	_	32.70
Hedera helix	2.0	1.40	_	0.50
Helianthemum	2.0	_	2.55	_
Inula viscosa	4.0	0.50	_	4.10
Lathyrus aphaca	8.0	0.10	0.10	0.30
Lily sp.	1.0	_	_	0.10
Linum bienne	2.0	_	0.10	0.30
Lithodora hispidula	4.0	_	2.00	2.43
Lolium perenne	1.0	_	_	0.10
Lotus sp.	8.0	_	0.96	1.62
Medicago sp.	18.0	0.70	4.98	5.32
Melica minuta	7.0	1.00	_	1.13
Mentha longifolia	4.0	0.90	_	1.65
Micromeria nervosa	1.0	_	_	2.50
Muscari comosum	2.0	_	_	3.25
Myosotis sp.	1.0	4.90	_	_
Nerium oleander	1.0	3.25	_	_
Olea europea	1.0	_	5.00	_
Orchids	8.0	0.57	0.10	0.27
Origanum dubium	5.0	0.50	_	1.36
Orlaya daucoides	1.0	6.00	_	_
Ornithopus compressus	10.0	0.20	2.78	0.72
Papaver postii	1.0	0.20	_	_
Pinus brutia	7.0	0.10	2.00	1.83

Pistachia terebinthus	4.0	1.00	_	0.47
Poa bulbosa	3.0	0.15	_	0.10
Poterium verrucosum	6.0	0.20	_	0.97
Prasium majus	2.0	_	1.25	_
Prunus dulcis	1.0	_	_	0.10
Psilurus incurvus	1.0	_	_	0.50
Pteridium aquilinum	6.0	6.93	_	2.49
Quercus alnifolia	4.0	3.35	_	13.50
Ranunculus ficaria	1.0	0.50	_	_
Rhamnus alaternus	1.0	_	2.14	_
Rubia tenuifolia	9.0	1.56	0.50	2.03
Rubus sanctus	4.0	3.02	_	17.00
Rumex sp.	1.0	_	_	0.60
Salvia verbenaca	1.0	_	_	0.00
Sarcopoterium spinosum	3.0	_	14.17	_
Scabious sp.	3.0	_	0.65	0.70
Sedum sp.	2.0	0.40	_	2.60
Selaginella denticulata	2.0	_	_	2.25
Senecio vulgaris	1.0	_	_	0.30
Silene vulgaris	2.0	_	_	1.38
Small composite sp.	15.0	0.43	0.42	1.31
Smilax aspera	3.0	0.63	_	_
Stellaria media	2.0	5.40	_	0.40
Styrax officinalis	1.0	1.30	_	_
Taeniatherum crinitum	1.0	1.00	_	_
Tamus communis	2.0	0.40	_	_
Taraxacum sp.	16.0	0.58	2.35	0.98
Teucrium kotschyanum	5.0	0.84	_	2.50
Thymus integer	2.0	_	_	2.22
Tolpis barbata	1.0	_	_	5.08
Tragopogon sinuatus	1.0	_	0.50	_
Trifolium clypeatum	2.0	_	_	4.80
Trifolium leucanthum	15.0	0.10	3.65	6.88
Trifolium pilulare	4.0	_	1.00	1.90
Trifolium sp.	9.0	1.30	6.62	9.49
Trifolium stellatum	12.0	_	5.18	7.67
Umbellifer sp.	14.0	0.23	0.50	0.96
Urginea maritima	4.0	_	_	0.82
Vicia cassia	9.0	0.18	0.15	0.90
Vicia hybrida	1.0	_	_	0.60
Vicia pubescens	11.0	0.25	0.25	0.88
Viola sp.	5.0	0.20	0.10	0.97
Vitis vinifera	1.0	_	_	2.55

MAY

Species	N	AYIA	AYMERC	LIMNITISPIA		VROISHA
Acer obtusifolium	3.0	6.00	–	0.60	–	–
Aegilops sp.	16.0	–	2.13	1.40	0.43	0.16
Aira elegans	11.0	0.10	0.10	0.20	–	0.16
Allium sp.	14.0	0.60	0.25	–	0.18	0.41
Anagallis arvensis	12.0	–	0.32	0.30	0.10	1.23
Anchusa sp.	3.0	–	–	2.15	–	0.75
Arisarum vulgare	3.0	0.10	0.10	–	–	0.30
Asparagus acutifolius	6.0	0.20	1.38	0.10	0.50	1.30
Asphodelus aestivus	28.0	2.55	–	3.36	0.78	2.37
Astragalus lusitanicus	4.0	0.70	2.35	–	0.50	0.20
Avena ludoviciana	24.0	0.20	2.21	1.70	0.99	0.48
Biscutella didyma	4.0	–	–	–	–	0.23
Briza maxima	15.0	0.65	0.15	0.33	0.83	0.15
Bromus sp.	96.0	1.40	8.26	4.17	2.59	3.74
Calendula arvensis	19.0	5.00	0.60	1.00	1.00	0.91
Cedrus libani	1.0	–	–	0.50	–	–
Centaurea aegialophila	2.0	–	–	0.10	–	0.10
Cistus creticus	33.0	19.00	4.60	18.73	15.89	10.37
Cistus ladanifer	1.0	1.50	–	–	–	–
Cistus monspeliensis	2.0	–	3.30	–	–	–
Cistus salviifolius	9.0	2.50	10.88	18.93	7.20	4.05
Large composite sp.	6.0	0.10	–	–	–	0.77
Crataegus sp.	6.0	–	–	0.20	7.00	0.13
Cyclamen cyprium	2.0	0.50	0.20	–	–	–
Cynosurus echinatus	7.0	5.00	–	0.10	0.10	0.88
Dactylis glomerata	9.0	–	6.35	–	5.08	0.65
Echinops spinosissiumus	22.0	0.50	0.20	0.88	0.30	0.39
Equisetum sp.	1.0	–	–	–	–	0.55
Filago sp.	1.0	–	–	–	–	0.10
Gagea sp.	1.0	–	–	–	–	0.90
Gallium aparine	15.0	0.60	0.60	2.13	1.93	1.02
Geranium purpureum	11.0	0.23	0.10	0.60	–	0.48
Gladiolus triphyllus	5.0	–	41.00	–	–	0.50
Grass	10.0	–	0.30	2.08	0.10	0.63
Grass shoots	4.0	0.80	2.50	8.40	–	0.20
Hedera helix	2.0	0.20	–	–	–	0.50
Helichrysum italicum	2.0	–	–	0.70	–	–
Hordeum sp.	4.0	–	10.20	1.00	–	0.50
Hordeum vulgaris	3.0	–	7.40	–	–	0.10
Hypericum sp.	1.0	–	–	–	–	0.20
Inula viscosa	9.0	0.50	1.25	4.15	–	2.83
Large composite sp.	4.0	–	–	1.60	–	0.30
Lathyrus aphaca	16.0	–	0.60	0.55	0.10	0.36
Lily sp.	1.0	–	0.10	–	–	–
Lithodora hispidula	7.0	–	–	–	0.30	2.68
Lolium perenne	8.0	–	0.26	3.60	–	0.41
Lotus sp.	12.0	–	1.05	0.13	–	1.00
Lupinus sp.	1.0	–	–	0.90	–	–
Medicago sp.	39.0	0.93	2.15	11.51	2.02	7.59
Melica minuta	9.0	0.83	0.50	0.40	0.10	0.87
Mentha longifolia	3.0	0.40	–	–	–	2.53
Micromeria nervosa	2.0	–	–	–	–	0.35
Muscari comosum	6.0	–	0.00	0.10	0.20	0.42
Myosotis sp.	1.0	0.60	–	–	–	–
Nerium oleander	1.0	4.00	–	–	–	–

Olea europea	2.0	–	2.00	–	6.00	–
Orchids	11.0	0.15	–	0.10	0.20	0.13
Origanum dubium	7.0	0.10	–	–	–	2.17
Orlaya daucoides	5.0	2.90	0.25	0.30	–	0.60
Ornithogallum sp.	1.0	–	–	–	–	0.10
Ornithopus compressus	22.0	0.10	1.67	2.27	0.32	0.46
Orobanche sp.	3.0	0.20	–	–	–	0.10
Papaver postii	1.0	0.80	–	–	–	–
Pinus brutia	17.0	–	2.75	3.46	2.30	1.54
Pistachia terebinthus	8.0	1.00	2.20	–	1.00	0.80
Poa bulbosa	12.0	1.25	0.10	0.60	0.15	0.30
Poterium verrucosum	10.0	0.30	0.65	0.30	–	0.52
Prasium majus	2.0	–	–	–	0.75	–
Prunus dulcis	1.0	–	–	–	–	0.10
Psilurus incurvus	10.0	–	0.80	–	2.03	3.07
Pteridium aquilinum	8.0	12.30	–	9.70	–	3.89
Quercus alnifolia	5.0	1.50	–	16.10	–	13.45
Quercus coccifera	1.0	–	0.35	–	–	–
Ranunculus ficaria	1.0	–	–	–	–	0.10
Rhamnus alaternus	1.0	–	–	–	2.00	–
Rubia tenuifolia	34.0	1.43	0.55	4.10	0.56	0.85
Rubus sanctus	4.0	3.75	3.50	–	–	13.80
Salvia verbenaca	3.0	–	–	0.10	–	0.50
Sarcopoterium spinosum	6.0	–	–	–	12.17	–
Scabious sp.	9.0	–	0.55	–	0.66	3.50
Scilla autumnalis	1.0	–	–	–	1.30	–
Sedum sp.	2.0	0.40	–	–	–	0.10
Selaginella denticulata	2.0	–	–	8.00	–	16.00
Senecio vulgaris	1.0	–	0.10	–	–	–
Silene vulgaris	5.0	–	0.20	1.45	–	0.50
Smilax aspera	3.0	0.55	0.10	–	–	–
Stellaria media	5.0	3.70	–	0.77	–	0.55
Styrax officinalis	3.0	0.35	–	–	–	0.60
Taeniatherum crinitum	3.0	–	–	–	3.27	–
Tamus communis	1.0	0.10	–	–	–	–
Taraxacum sp.	33.0	0.28	0.59	0.40	0.56	1.36
Teucrium kotschyanum	5.0	0.33	–	–	0.50	2.40
Thymus integer	3.0	–	–	0.10	–	2.75
Tolpis barbata	3.0	–	0.10	–	0.20	0.10
Tragopogon sinuatus	5.0	–	0.22	0.90	0.20	0.30
Trifolium clypeatum	4.0	–	0.10	1.10	–	3.03
Trifolium leucanthum	26.0	–	4.43	4.44	1.38	3.12
Trifolium pamphylicum	6.0	–	–	0.80	0.18	0.80
Trifolium pilulare	21.0	–	3.35	9.74	4.59	3.25
Trifolium sp.	27.0	0.30	4.13	4.30	1.03	4.93
Trifolium stellatum	19.0	–	1.00	2.20	0.60	4.03
Triticum sp.	2.0	–	0.55	–	–	–
Umbellifer sp.	33.0	0.15	0.39	0.50	0.31	0.70
Urginea maritima	10.0	–	0.90	0.65	0.55	0.60
Vicia cassia	18.0	0.30	2.34	0.63	0.10	0.83
Vicia hybrida	7.0	–	3.00	0.20	–	1.98
Vicia lunata	1.0	–	–	0.20	–	–
Vicia pubescens	18.0	–	4.58	0.95	0.10	0.81
Viola sp.	5.0	–	–	–	–	0.24
Vitis vinifera	1.0	–	–	–	–	5.25

JUNE

Species	N	AYIA	AYMERC	LIMNITISPIA		VROISHA
Acer obtusifolium	6.0	9.59	_	0.40	_	_
Aegilops sp.	13.0	0.20	0.10	_	0.40	_
Aira elegans	17.0	0.34	0.10	0.18	0.15	0.18
Allium sp.	24.0	0.39	0.22	0.13	0.41	0.32
Anagallis arvensis	3.0	0.20	_	_	0.10	0.50
Anchusa sp.	3.0	_	_	1.60	_	1.00
Asparagus acutifolius	8.0	0.55	1.11	0.50	0.50	0.60
Asphodelus aestivus	37.0	2.39	0.10	3.47	1.33	2.44
Astragalus lusitanicus	3.0	0.10	2.60	_	0.10	_
Avena ludoviciana	32.0	0.10	2.93	1.38	1.91	0.68
Biscutella didyma	1.0	_	_	_	0.10	_
Briza maxima	20.0	0.37	0.20	0.13	0.40	0.10
Bromus sp.	124.0	1.61	15.15	2.65	3.31	7.52
Calendula arvensis	3.0	0.25	_	_	_	0.60
Cedrus libani	1.0	_	_	0.50	_	_
Centaurea aegialophila	4.0	0.20	_	0.10	_	_
Cistus creticus	45.0	9.06	3.21	17.64	10.43	10.84
Cistus ladanifer	1.0	1.50	_	_	_	_
Cistus monspeliensis	2.0	_	2.36	_	_	_
Cistus salviifolius	13.0	8.88	8.97	6.25	4.53	_
Large composite sp.	11.0	_	0.50	2.22	0.10	0.45
Crataegus sp.	9.0	0.60	_	0.50	2.33	0.13
Cyclamen cyprium	1.0	0.10	_	_	_	_
Cynosurus echinatus	12.0	2.32	_	0.30	0.30	0.43
Dactylis glomerata	14.0	0.30	9.50	_	3.74	0.25
Echinops spinosissiumus	18.0	0.35	0.30	1.74	1.33	0.26
Equisetum sp.	1.0	_	_	_	_	1.20
Filago sp.	15.0	0.63	_	_	0.76	0.20
Gagea sp.	1.0	_	_	_	2.10	_
Gallium aparine	14.0	3.68	_	1.83	1.18	0.60
Gallium suberosum	1.0	_	_	_	1.50	_
Geranium purpureum	5.0	0.40	_	_	0.10	0.11
Gladiolus triphyllus	3.0	0.70	_	_	_	0.43
Grass	28.0	2.47	0.10	6.44	2.03	0.57
Grass shoots	2.0	_	_	_	0.50	0.30
Hedera helix	4.0	0.15	_	_	0.10	0.10
Helichrysum italicum	2.0	_	_	0.55	_	_
Hordeum sp.	4.0	_	13.30	_	3.10	0.20
Hypericum sp.	2.0	_	0.10	_	3.60	_
Inula viscosa	10.0	0.30	1.67	4.14	_	3.70
Lathyrus aphaca	14.0	0.20	0.32	1.15	0.23	0.30
Lithodora hispidula	10.0	3.50	_	_	1.35	4.47
Lolium perenne	5.0	0.10	1.30	3.30	_	0.33
Lonicera etrusca	1.0	0.10	_	_	_	_
Lotus sp.	9.0	_	0.40	_	0.33	0.65
Lupinus sp.	1.0	_	_	0.60	_	_
Medicago sp.	47.0	2.07	0.80	7.86	1.84	4.22
Melica minuta	14.0	0.52	0.33	_	0.13	0.31
Mentha longifolia	2.0	_	_	_	_	0.90
Micromeria nervosa	4.0	_	_	_	0.95	0.50
Muscari comosum	5.0	_	0.50	_	0.20	0.40
Myrtus communis	2.0	3.50	_	_	12.50	_
Nerium oleander	1.0	3.00	_	_	_	_
Olea europea	4.0	_	1.60	_	6.55	_
Orchids	6.0	_	0.10	0.10	0.10	0.10

Origanum dubium	6.0	0.70	–	–	–	1.65
Orlaya daucoides	6.0	1.30	0.30	–	0.45	–
Ornithopus compressus	19.0	0.10	0.40	0.57	0.36	0.10
Orobanche sp.	2.0	0.10	–	–	–	0.10
Papaver postii	1.0	0.30	–	–	–	–
Pinus brutia	18.0	–	2.25	2.41	2.15	2.73
Pistachia terebinthus	8.0	4.80	1.38	–	5.20	0.41
Poa bulbosa	16.0	0.58	0.10	0.52	0.10	0.25
Poterium verrucosum	11.0	0.10	0.21	0.15	–	0.23
Psilurus incurvus	8.0	–	2.10	–	1.48	3.40
Pteridium aquilinum	7.0	14.75	–	5.50	–	3.37
Quercus alnifolia	8.0	7.45	–	28.20	–	21.60
Quercus coccifera	2.0	–	0.22	–	0.30	–
Rhamnus alaternus	1.0	–	–	–	2.00	–
Rubia tenuifolia	32.0	1.06	0.22	0.45	0.61	0.93
Rubus sanctus	6.0	2.92	2.60	–	–	8.40
Rumex sp.	1.0	–	–	0.30	–	–
Salvia verbenaca	3.0	0.13	–	–	–	–
Sarcopoterium spinosum	13.0	8.20	–	–	12.78	–
Scabious sp.	8.0	–	0.20	–	0.44	–
Scilla autumnalis	14.0	0.10	–	–	2.33	–
Sedum sp.	7.0	2.35	–	0.25	0.25	0.13
Silene vulgaris	4.0	–	0.10	0.65	–	0.10
Smilax aspera	2.0	0.50	–	–	–	–
Stellaria media	4.0	2.72	–	0.70	–	–
Styrax officinalis	2.0	0.53	–	–	–	–
Taeniatherum crinitum	7.0	–	–	–	3.13	–
Taraxacum sp.	40.0	0.50	0.28	0.43	1.08	0.71
Teucrium kotschyanum	11.0	0.89	–	2.00	0.40	1.50
Thymus capitatus	2.0	–	–	–	3.60	–
Thymus integer	9.0	0.45	–	0.50	0.75	1.00
Tolpis barbata	5.0	–	–	–	0.24	–
Tragopogon sinuatus	4.0	0.10	0.25	–	–	0.20
Trifolium clypeatum	1.0	–	–	1.90	–	–
Trifolium leucanthum	28.0	0.48	2.25	3.86	4.23	2.18
Trifolium pamphylicum	8.0	–	–	1.83	0.23	0.40
Trifolium pilulare	22.0	–	1.67	6.16	2.18	3.00
Trifolium sp.	35.0	0.28	–	5.33	2.58	2.06
Trifolium stellatum	16.0	–	0.75	0.60	0.33	1.21
Umbellifer sp.	36.0	0.55	0.10	0.60	0.23	0.61
Urginea maritima	7.0	0.20	–	0.40	0.35	0.30
Vicia cassia	19.0	0.20	0.93	1.08	0.20	0.18
Vicia pubescens	3.0	–	–	0.70	–	1.30
Viola sp.	1.0	0.40	–	–	–	–
Vitis vinifera	1.0	–	–	–	–	3.10

JULY

Species	N	AYIA	AYMERC	VROISHA
Acer obtusifolium	4.0	8.65	_	_
Aegilops sp.	1.0	_	1.00	_
Aira elegans	5.0	0.32	_	_
Allium sp.	5.0	0.28	_	_
Arbutus andrachne	1.0	0.50	_	_
Asparagus acutifolius	3.0	0.33	_	_
Asphodelus aestivus	8.0	1.94	_	6.00
Astragalus lusitanicus	1.0	0.10	_	_
Avena ludoviciana	5.0	0.10	2.30	1.05
Biscutella didyma	1.0	_	_	0.30
Briza maxima	1.0	0.50	_	_
Bromus sp.	15.0	1.08	16.10	6.00
Calendula arvensis	1.0	0.10	_	_
Cistus creticus	11.0	9.59	_	11.05
Cistus ladanifer	1.0	3.00	_	_
Cistus salviifolius	2.0	7.75	_	_
Large composite sp.	3.0	_	0.10	0.70
Crataegus sp.	3.0	0.30	_	0.25
Cynosurus echinatus	4.0	1.03	_	0.90
Dactylis glomerata	2.0	0.10	_	0.60
Echinops spinosissiumus	2.0	0.20	_	0.80
Equisetum sp.	1.0	_	_	1.60
Filago sp.	3.0	1.30	_	0.10
Gallium aparine	3.0	_	0.20	0.90
Geranium purpureum	2.0	0.15	_	_
Gladiolus triphyllus	1.0	0.40	_	_
Grass	2.0	1.50	_	_
Grass shoots	1.0	0.90	_	_
Hedera helix	1.0	_	_	0.30
Inula viscosa	2.0	0.50	_	7.00
Lathyrus aphaca	3.0	0.10	0.30	0.30
Lithodora hispidula	4.0	2.50	_	3.73
Lotus sp.	1.0	_	0.20	_
Medicago sp.	10.0	2.16	2.30	8.60
Melica minuta	6.0	0.42	_	0.20
Mentha longifolia	1.0	_	_	0.80
Muscari comosum	2.0	_	_	0.40
Myrtus communis	1.0	4.50	_	_
Nerium oleander	1.0	3.00	_	_
Olea europea	1.0	_	1.50	_
Origanum dubium	2.0	_	_	0.85
Orlaya daucoides	1.0	2.00	_	_
Ornithopus compressus	3.0	_	1.70	0.30
Orobanche sp.	2.0	0.10	_	_
Papaver postii	1.0	0.50	_	_
Pinus brutia	2.0	_	3.00	0.10
Pistachia terebinthus	2.0	6.30	_	_
Poa bulbosa	4.0	0.90	_	0.10
Poterium verrucosum	4.0	0.10	0.10	0.50
Psilurus incurvus	2.0	1.35	_	_
Pteridium aquilinum	3.0	29.80	_	6.00
Quercus alnifolia	4.0	8.73	_	19.00
Rubia tenuifolia	10.0	1.00	_	1.07
Rubus sanctus	3.0	5.90	_	17.80
Salvia verbenaca	4.0	0.10	_	1.30

Scilla autumnalis	2.0	0.10	_	2.50
Sedum sp.	3.0	0.60	_	_
Silene vulgaris	2.0	0.10	_	0.40
Smilax aspera	2.0	0.55	_	_
Stellaria media	4.0	3.67	_	0.80
Styrax officinalis	1.0	0.20	_	_
Taraxacum sp.	10.0	0.20	0.50	0.55
Teucrium kotschyanum	6.0	0.30	_	2.30
Thymus integer	1.0	_	_	1.50
Tolpis barbata	1.0	_	0.10	_
Tragopogon sinuatus	1.0	_	_	0.50
Trifolium clypeatum	3.0	_	0.20	1.85
Trifolium leucanthum	7.0	0.27	3.90	5.47
Trifolium pilulare	3.0	_	9.80	0.55
Trifolium sp.	6.0	0.17	1.00	9.80
Trifolium stellatum	2.0	_	1.20	0.10
Umbellifer sp.	5.0	0.20	0.20	0.10
Urginea maritima	2.0	0.20	_	1.50
Vicia cassia	1.0	_	1.70	_
Vicia pubescens	2.0	0.10	_	1.00

AUGUST

Species	N	AYIA	LIMNITIS	PIA
Acer obtusifolium	2.0	11.20	–	–
Aegilops sp.	3.0	–	0.10	0.10
Aira elegans	2.0	0.10	–	0.20
Anchusa sp.	2.0	–	2.00	–
Asparagus acutifolius	3.0	0.50	0.30	–
Asphodelus aestivus	15.0	11.30	3.46	0.89
Astragalus lusitanicus	1.0	–	–	0.10
Avena ludoviciana	12.0	0.10	3.72	1.10
Briza maxima	11.0	–	0.17	0.21
Bromus sp.	56.0	–	6.34	1.18
Calendula arvensis	1.0	–	0.20	–
Cedrus libani	1.0	–	0.50	–
Cistus creticus	21.0	13.95	14.92	9.84
Cistus salviifolius	6.0	6.00	2.23	3.00
Large composite sp.	2.0	–	4.25	–
Crataegus sp.	3.0	–	0.20	5.05
Cynosurus echinatus	5.0	0.10	–	0.20
Dactylis glomerata	4.0	–	–	0.40
Echinops spinosissiumus	7.0	0.10	1.26	0.10
Filago sp.	3.0	–	–	0.20
Gallium aparine	4.0	–	3.80	2.85
Grass	2.0	–	10.65	–
Grass shoots	1.0	1.30	–	–
Hedera helix	1.0	–	–	0.10
Helichrysum italicum	3.0	–	0.23	–
Inula viscosa	4.0	–	4.65	–
Large composite sp.	1.0	–	0.60	–
Lathyrus aphaca	2.0	–	0.80	–
Lithodora hispidula	4.0	–	–	1.80
Lolium perenne	2.0	0.10	3.00	–
Lotus sp.	1.0	–	1.00	–
Medicago sp.	17.0	0.20	4.36	0.94
Melica minuta	2.0	0.10	1.20	–
Micromeria nervosa	2.0	–	–	0.65
Myrtus communis	1.0	–	–	13.50
Nerium oleander	1.0	5.00	–	–
Olea europea	1.0	–	–	9.90
Orchids	1.0	–	0.10	–
Orlaya daucoides	3.0	–	1.65	0.10
Ornithopus compressus	1.0	–	0.13	–
Pinus brutia	9.0	–	4.74	2.28
Pistachia terebinthus	3.0	–	–	4.47
Poa bulbosa	8.0	0.10	0.44	0.25
Psilurus incurvus	5.0	–	1.98	0.50
Pteridium aquilinum	2.0	2.00	5.00	–
Quercus alnifolia	3.0	5.10	17.00	–
Rhamnus alaternus	1.0	–	–	0.50
Rubia tenuifolia	14.0	0.30	0.37	0.58
Rubus sanctus	1.0	0.30	–	–
Rumex sp.	1.0	–	0.30	–
Sarcopoterium spinosum	8.0	–	–	13.06
Scilla autumnalis	13.0	–	0.20	1.70
Sedum sp.	6.0	0.10	0.13	3.30
Smilax aspera	1.0	0.20	–	–
Taeniatherum crinitum	11.0	–	–	2.52

Taraxacum sp.	16.0	–	0.57	0.64
Teucrium kotschyanum	4.0	1.05	–	0.20
Thymus integer	1.0	–	–	2.00
Trifolium clypeatum	1.0	–	1.50	–
Trifolium leucanthum	8.0	–	0.92	0.50
Trifolium pamphylicum	1.0	–	0.50	–
Trifolium pilulare	4.0	–	4.55	–
Trifolium sp.	14.0	–	1.55	0.91
Trifolium stellatum	1.0	–	0.13	–
Umbellifer sp.	3.0	–	–	0.13
Urginea maritima	2.0	–	–	0.15
Vicia cassia	6.0	0.10	1.15	–
Vicia lunata	1.0	–	–	1.70

SEPTEMBER

Species	N	AYIA	AYMERC	PIA	VROISHA
Acer obtusifolium	1.0	2.60	–	–	–
Aegilops sp.	5.0	–	0.10	0.50	0.10
Aira elegans	6.0	0.20	0.10	0.10	0.25
Allium sp.	8.0	–	0.15	0.17	0.63
Anagallis arvensis	2.0	–	–	–	0.10
Anchusa sp.	1.0	–	–	–	0.50
Asparagus acutifolius	2.0	0.20	0.56	–	–
Asphodelus aestivus	10.0	–	–	1.42	3.56
Astragalus lusitanicus	3.0	0.20	2.60	0.50	–
Avena ludoviciana	14.0	–	5.80	2.68	0.88
Briza maxima	5.0	–	–	0.65	0.20
Bromus sp.	53.0	0.40	7.38	7.18	8.27
Centaurea aegialophila	1.0	–	–	–	0.10
Cistus creticus	16.0	9.40	5.19	17.78	7.16
Cistus ladanifer	1.0	3.50	–	–	–
Cistus monspeliensis	2.0	–	2.75	–	–
Cistus salviifolius	3.0	3.50	16.40	9.00	–
Large composite sp.	5.0	–	0.50	1.00	0.37
Crataegus sp.	1.0	–	–	–	0.20
Cynosurus echinatus	5.0	0.85	–	–	0.37
Dactylis glomerata	8.0	–	7.00	3.95	0.10
Echinops spinosissiumus	9.0	–	0.60	2.15	0.36
Gallium aparine	2.0	–	–	–	0.65
Grass shoots	1.0	–	–	–	0.40
Hordeum sp.	1.0	–	27.50	–	–
Hordeum vulgaris	1.0	–	–	9.50	–
Hypericum sp.	1.0	–	–	1.50	–
Inula viscosa	4.0	0.50	2.78	–	2.00
Lathyrus aphaca	3.0	–	–	–	0.33
Linum bienne	1.0	–	–	–	0.10
Lithodora hispidula	3.0	–	–	1.00	1.70
Lolium perenne	1.0	–	–	–	0.20
Lotus sp.	3.0	–	–	0.35	0.10
Medicago sp.	15.0	–	2.50	1.06	2.58
Melica minuta	3.0	0.80	0.10	–	0.10
Micromeria nervosa	1.0	–	–	–	1.20
Muscari comosum	1.0	–	–	0.10	–
Olea europea	3.0	–	1.25	9.90	–
Origanum dubium	4.0	0.10	–	–	1.53
Orlaya daucoides	2.0	0.30	–	0.10	–
Ornithopus compressus	4.0	–	0.20	0.95	–
Pinus brutia	5.0	–	3.00	2.00	4.25
Pistachia terebinthus	5.0	4.50	1.11	–	1.50
Poa bulbosa	5.0	0.50	–	2.00	0.20
Prunus dulcis	1.0	–	–	–	0.10
Psilurus incurvus	5.0	1.60	–	3.85	0.80
Pteridium aquilinum	4.0	17.80	–	–	2.93
Quercus alnifolia	2.0	1.00	–	–	22.00
Quercus coccifera	1.0	–	–	0.50	–
Rhamnus alaternus	1.0	–	–	3.00	–
Rubia tenuifolia	10.0	1.25	0.10	0.30	0.43
Rubus sanctus	3.0	4.25	2.89	–	–
Rumex sp.	1.0	–	–	–	0.20
Salvia verbenaca	2.0	–	–	–	1.85
Sarcopoterium spinosum	4.0	–	–	11.68	–

Scabious sp.	2.0	–	–	0.20	–
Scilla autumnalis	4.0	–	0.20	3.20	0.60
Sedum sp.	5.0	0.25	2.50	1.50	0.10
Selaginella denticulata	1.0	–	–	–	2.50
Silene vulgaris	1.0	–	0.10	–	–
Smilax aspera	2.0	0.60	–	–	–
Stellaria media	3.0	2.20	–	–	0.10
Styrax officinalis	2.0	0.20	–	–	–
Taraxacum sp.	15.0	–	0.40	0.48	1.39
Teucrium kotschyanum	3.0	0.35	–	–	1.20
Thymus integer	1.0	–	–	–	0.10
Tolpis barbata	1.0	–	–	–	0.20
Trifolium clypeatum	2.0	0.30	0.10	–	–
Trifolium leucanthum	16.0	–	2.55	2.18	0.56
Trifolium pilulare	6.0	–	2.30	2.25	1.13
Trifolium sp.	9.0	–	1.30	1.50	1.18
Trifolium stellatum	3.0	–	0.20	0.20	0.20
Umbellifer sp.	6.0	–	0.15	–	0.28
Urginea maritima	4.0	–	–	–	0.30
Vicia cassia	5.0	–	1.50	1.10	0.45
Vicia pubescens	2.0	–	–	–	0.30
Vitis vinifera	1.0	–	–	–	3.40

OCTOBER

Species	N	AYIA	PIA	VROISHA
Acer obtusifolium	3.0	7.10	_	_
Asparagus acutifolius	3.0	0.10	0.50	0.60
Asphodelus aestivus	7.0	7.50	0.70	2.33
Astragalus lusitanicus	2.0	0.50	2.00	_
Avena ludoviciana	3.0	_	1.55	0.10
Briza maxima	1.0	_	0.50	_
Bromus sp.	13.0	_	5.06	18.65
Calendula arvensis	4.0	0.10	_	0.23
Cistus creticus	14.0	9.67	18.65	13.37
Cistus ladanifer	1.0	3.50	_	_
Cistus salviifolius	3.0	6.75	9.00	_
Large composite sp.	1.0	_	_	0.80
Crataegus sp.	3.0	_	0.10	0.30
Crocus sp.	2.0	0.20	0.10	_
Cynosurus echinatus	2.0	0.20	_	0.10
Dactylis glomerata	6.0	_	6.80	0.20
Dicot shoots	10.0	_	12.48	15.30
Grasses	1.0	_	11.30	_
Echinops spinosissiumus	4.0	0.40	_	0.40
Equisetum sp.	1.0	_	_	1.10
Gladiolus triphyllus	1.0	_	_	0.30
Grass	1.0	0.10	_	_
Grass shoots	9.0	_	11.76	4.18
Inula viscosa	4.0	1.00	_	6.83
Lathyrus aphaca	1.0	_	_	0.10
Lithodora hispidula	4.0	_	1.00	3.67
Melica minuta	5.0	0.27	_	0.45
Mentha longifolia	2.0	_	_	0.90
Micromeria nervosa	1.0	_	_	1.10
Muscari comosum	1.0	_	_	0.10
Nerium oleander	1.0	5.00	_	_
Olea europea	1.0	_	7.00	_
Origanum dubium	4.0	0.60	_	1.17
Pinus brutia	3.0	_	3.00	0.80
Pistachia terebinthus	1.0	_	_	0.50
Poa bulbosa	1.0	_	_	0.10
Poterium verrucosum	1.0	_	_	0.10
Psilurus incurvus	2.0	_	0.60	_
Pteridium aquilinum	3.0	1.00	_	3.25
Quercus alnifolia	2.0	5.10	_	17.80
Rhamnus alaternus	1.0	_	2.00	_
Rubia tenuifolia	5.0	0.40	_	1.65
Rubus sanctus	3.0	1.60	_	16.00
Salvia verbenaca	2.0	_	_	0.10
Sarcopoterium spinosum	3.0	_	11.50	_
Scilla autumnalis	1.0	_	2.10	_
Silene vulgaris	1.0	_	_	0.40
Smilax aspera	2.0	0.15	_	_
Styrax officinalis	1.0	0.70	_	_
Taraxacum sp.	7.0	_	0.43	1.20
Teucrium kotschyanum	4.0	1.23	_	3.00
Thymus integer	2.0	_	_	3.25
Trifolium sp.	2.0	_	0.60	0.80
Vicia cassia	1.0	_	_	0.10
Vitis vinifera	1.0	_	_	4.60

NOVEMBER

Species	N	AYIA	PIA	VROISHA
Acer obtusifolium	3.0	7.77	_	_
Anchusa sp.	1.0	_	_	1.00
Arisarum vulgare	8.0	_	1.60	1.58
Asparagus acutifolius	3.0	0.13	_	0.90
Asphodelus aestivus	11.0	1.25	0.25	0.93
Astragalus lusitanicus	2.0	0.50	1.50	_
Bromus sp.	6.0	1.50	4.00	11.90
Calendula arvensis	4.0	0.10	_	4.47
Cistus creticus	16.0	10.64	21.75	14.01
Cistus ladanifer	1.0	3.00	_	_
Cistus salviifolius	2.0	8.18	_	_
Large composite sp.	2.0	_	_	0.20
Crataegus sp.	4.0	_	1.00	0.15
Crocus sp.	1.0	_	0.40	_
Cyclamen cyprium	2.0	0.45	_	_
Cynosurus echinatus	2.0	2.80	_	0.50
Dactylis glomerata	7.0	_	11.65	1.18
Dicot shoots	15.0	1.94	6.80	4.24
Grasses	5.0	_	_	12.24
Echinops spinosissiumus	3.0	0.40	_	0.45
Equisetum sp.	1.0	_	_	2.95
Gallium aparine	6.0	1.10	_	0.59
Geranium purpureum	5.0	0.35	_	0.33
Gladiolus triphyllus	1.0	_	0.10	_
Grass shoots	16.0	7.15	23.14	12.41
Inula viscosa	5.0	0.50	_	3.33
Lathyrus aphaca	7.0	0.15	0.20	0.49
Lithodora hispidula	4.0	_	1.50	3.78
Lonicera etrusca	1.0	0.10	_	_
Lotus sp.	4.0	_	32.00	2.03
Medicago sp.	3.0	0.35	_	13.50
Melica minuta	3.0	0.52	_	_
Mentha longifolia	2.0	_	_	2.00
Micromeria nervosa	1.0	_	_	2.10
Muscari comosum	1.0	_	_	0.10
Nerium oleander	1.0	3.50	_	_
Olea europea	1.0	_	7.00	_
Orchids	4.0	_	0.10	0.22
Origanum dubium	4.0	0.50	_	1.65
Orlaya daucoides	3.0	0.10	_	0.30
Ornithopus compressus	2.0	_	0.80	0.10
Pinus brutia	4.0	_	3.00	2.22
Pistachia terebinthus	1.0	1.85	_	_
Poa bulbosa	3.0	0.55	_	0.10
Poterium verrucosum	6.0	0.30	_	0.37
Psilurus incurvus	2.0	_	_	1.35
Pteridium aquilinum	4.0	8.25	_	3.43
Quercus alnifolia	3.0	3.78	_	24.20
Ranunculus sp.	1.0	_	_	0.20
Rhamnus alaternus	2.0	_	1.25	_
Rubia tenuifolia	6.0	0.54	_	1.60
Rubus sanctus	4.0	2.78	_	17.00
Salvia verbenaca	1.0	_	_	0.75
Sarcopoterium spinosum	3.0	_	11.23	_
Scilla autumnalis	1.0	_	0.40	_

Senecio vulgaris	1.0	–	–	0.50
Silene vulgaris	1.0	–	–	2.00
Smilax aspera	2.0	0.43	–	–
Stellaria media	1.0	–	–	0.10
Styrax officinalis	1.0	0.60	–	–
Taraxacum sp.	18.0	0.20	2.70	1.52
Teucrium kotschyanum	5.0	1.26	–	2.10
Thymus integer	2.0	–	–	2.80
Trifolium sp.	14.0	0.20	7.98	18.54
Umbellifer sp.	11.0	0.20	2.00	1.61
Urginea maritima	2.0	–	0.10	0.10
Vicia cassia	11.0	0.10	0.13	0.68
Vicia pubescens	3.0	–	–	0.70
Vitis vinifera	1.0	–	–	2.00

DECEMBER

Species	N	AYIA	PIA	VROISHA
Acer obtusifolium	2.0	10.73	–	–
Anchusa sp.	1.0	–	–	0.50
Anemone coronaria	1.0	–	8.35	–
Arisarum vulgare	9.0	–	1.58	1.99
Asparagus acutifolius	3.0	0.13	–	1.05
Asphodelus aestivus	15.0	2.00	0.58	2.26
Astragalus lusitanicus	1.0	–	2.00	–
Avena ludoviciana	3.0	–	4.55	–
Briza maxima	1.0	–	0.50	–
Calendula arvensis	16.0	0.25	2.90	2.54
Centaurea aegialophila	1.0	0.15	–	–
Cistus creticus	15.0	11.23	19.20	14.87
Cistus salviifolius	2.0	3.75	8.25	–
Large composite sp.	4.0	–	–	1.13
Crataegus sp.	3.0	–	0.75	0.13
Cyclamen cyprium	2.0	1.83	–	–
Dactylis glomerata	6.0	–	13.28	1.08
Dicot shoots	4.0	0.98	1.25	–
Echinops spinosissiumus	6.0	0.90	–	0.34
Equisetum sp.	1.0	–	–	3.10
Euphorbia sp.	1.0	–	–	0.40
Gallium aparine	15.0	4.23	0.40	0.85
Geranium purpureum	8.0	1.28	0.33	0.29
Gladiolus triphyllus	1.0	–	0.80	–
Grass shoots	17.0	5.89	23.06	15.62
Hypericum sp.	1.0	–	–	0.20
Inula viscosa	4.0	–	–	3.34
Lathyrus aphaca	13.0	0.13	0.32	0.50
Lily sp.	2.0	0.20	–	0.20
Lithodora hispidula	4.0	–	1.25	4.45
Lonicera etrusca	1.0	0.10	–	–
Lotus sp.	9.0	–	3.08	2.44
Medicago sp.	6.0	0.40	–	2.14
Melica minuta	5.0	1.20	–	0.65
Mentha longifolia	2.0	–	–	2.60
Micromeria nervosa	1.0	–	–	1.50
Muscari comosum	1.0	–	–	0.10
Nerium oleander	1.0	4.00	–	–
Olea europea	1.0	–	4.00	–
Orchids	6.0	0.10	0.10	0.29
Origanum dubium	3.0	–	–	1.95
Orlaya daucoides	2.0	0.65	–	0.35
Ornithopus compressus	5.0	–	2.88	0.10
Pinus brutia	4.0	–	2.75	2.70
Pistachia terebinthus	1.0	1.05	–	–
Poa bulbosa	1.0	–	–	0.30
Poterium verrucosum	6.0	–	–	0.65
Pteridium aquilinum	1.0	–	–	0.30
Quercus alnifolia	3.0	3.50	–	21.10
Ranunculus ficaria	1.0	–	–	1.60
Ranunculus sp.	9.0	0.55	4.18	0.62
Rhamnus alaternus	3.0	–	1.20	–
Rubia tenuifolia	5.0	0.82	–	1.68
Rubus sanctus	3.0	2.65	–	17.45
Rumex sp.	2.0	–	–	0.55

Salvia verbenaca	1.0	–	–	1.00
Sarcopoterium spinosum	3.0	–	12.32	–
Scilla autumnalis	1.0	–	0.70	–
Senecio vulgaris	4.0	–	0.24	0.10
Silene vulgaris	1.0	–	–	1.70
Smilax aspera	2.0	0.65	–	–
Stellaria media	1.0	–	–	2.00
Taraxacum sp.	9.0	0.48	4.35	2.82
Teucrium kotschyanum	4.0	1.22	–	2.00
Thymus integer	2.0	–	–	3.45
Trifolium sp.	16.0	0.22	9.12	13.69
Umbellifer sp.	11.0	–	1.12	3.19
Urginea maritima	2.0	–	0.13	–
Vicia cassia	12.0	0.10	0.54	0.49
Vicia lunata	1.0	–	–	0.10
Vicia pubescens	6.0	–	0.30	0.80
Vitis vinifera	1.0	–	–	0.20

Appendix 2

Species found in the botanical surveys.

* denotes whether the species was eaten by mouflon: either noted during observation of the animals, or by examination of plants in the field. All plant names taken from Meikle (1977 & 1985) Flora of Cyprus vols. I and II, after Genera Plantarum (1862-83) of J.D. Hooker and G. Bentham.

The classification of the plants into Tree (T), Shrub (S), Ephemeral (E) and Grass (G) as used in Chapter 2 are shown under column A.

The classification into epidermally recognisable types (see chapter 4) are in column B. These types are as follows: Grasses (G), *Cistus* spp. (C), *Lithodora hirsuta* (Lh), Broadleaved Trees except for those in this list under another name (B), *Pinus brutia* (Pb), *Rubus sanctus* (Rs), Forbs (F), Non-graminaceous monocotyledons (M), *Teucrium kotschyanum* (Tk), *Pistacia terebinthus* and *Trifolium clypeatum* (PT), *Asphodelus aestivus* (Aa), *Styrax officinalis* (So), *Cedrus libani* (Cl), *Platanus orientalis* (Po), *Quercus alnifolia* (Qa), *Astragalus lusitanicus* (Al). A species not found in the plots but which was nevertheless in the habitat was *Myrtus communis* .

	SPECIES.	A.	B.
	Acer obtusifolium Sibth *et* Sm.	T	B
	Aegilops sp.	G	G
	Aira elegans Willd *ex* Gaud.	G	G
	Allium sp.	E	M
	Alnus orientalis Decne.	T	B
	Anagallis arvensis L.	E	F
*	*Anchusa* sp.	E	F
	Anemone coronaria L.	E	F
*	*Arbutus andrachne* L.	T	B
	Arisarum vulgare Targ.-Tozz.	E	M
	Asparagus acutifolius L.	S	M
*	*Asphodelus aestivus* Brot.	E	Aa
*	*Astragalus lusitanicus* (Lam) ssp *orientalis* (Chater *et* Meikle).	E	Al
*	*Avena ludoviciana* Durieu	G	G
	Biscutella didyma L.	E	F
	Briza maxima L.	G	G
*	*Bromus* spp.	G	G
*	*Calendula arvensis* L.	E	F
	Calycotome villosa Poir.	T	F
	Capsella bursa-pastoris L	E	F
	Cedrus libani s sp. *brevifolia* Hook.f.	T	Cb
	Centaurea aegialophila Wagenitz.	E	F
*	*Cistus creticus* (L.) *var creticus* (L.)	S	C
	Cistus ladanifer L.	S	C
*	*Cistus monspeliensis* L.	S	C
*	*Cistus salviifolius* L.	S	C
*	*Crataegus azarolus* L.	T	F
*	*Crataegus monogyna* Jacq.	T	F
	Crocus sp.	E	M
	Cyclamen cyprium Kotschy	E	F
	Cynosurus echinatus L.	G	G
*	*Dactylis glomerata* L.	G	G
*	Dicot shoots	E	F
	Equisetum sp.	E	F
	Euphorbia sp.	E	F
*	*Ficus carica* L.	T	F
	Filago sp.	E	F
	Gagea sp.	E	M
*	*Gallium aparine* L.	E	F
*	*Gallium suberosum*	S	F

*	*Genista sphacelata* Decne.	T	F
	Geranium purpureum Vill.	E	F
	Gladiolus triphyllus (Sm) Ker-Gawler.	E	M
*	Grass shoots	G	G
	Hedera helix L.	S	F
	Helianthemum sp.	S	F
*	*Helichrysum italicum* (Roth) Don.	S	F
*	*Hordeum vulgare*	G	G
	Hypericum sp.	E	F
*	*Inula viscosa* L.	S	F
	Juglans regia L.	T	B
	Lathyrus aphaca L.	E	F
	Linum bienne Mill.	E	F
*	*Lithodora hispidula* (Sm) Griseb.	S	Lh
	Lolium perenne L.	G	G
	Lonicera etrusca Santi.	E	F
*	*Lotus* spp.	E	F
	Lupinus sp.	E	F
*	*Medicago* sp.	E	F
*	*Melica minuta* L.	G	G
*	*Menthes longifolia* (L.) ssp. *cyprica* H. Braun.	E	F
	Micromeria nervosa (Desf.) Benth.	E	F
*	*Muscari comosum* L.	E	M
*	*Myosotis* sp	E	F
	Narcissus tazetta L.	E	M
	Nerium oleander L.	T	F
*	*Olea europea* L.	T	B
*	Orchids	E	M
	Origanum dubium Boiss.	S	F
*	*Orlaya daucoides*	E	F
	Ornithogallum sp.	E	M
	Ornithopus compressus (L)	E	F
	Orobanche sp.	E	F
	Papaver postii Fedde.	E	F
	Phagnalon rupestre L.	S	F
	Phlomis cypria Post.	S	F
*	*Pinus brutia* Tenore	T	Pb
*	*Pistacia terebinthus* L.	T	PT
*	*Platanus orientalis* L.	T	Po
*	*Poa* sp.	G	G
*	*Poa bulbosa* L.	G	G
	Poterium verrucosum (Ehrenb.) Link *ex* G. Don	E	F
	Prasium majus L.	S	F
*	*Prunus dulcis* Mill.	T	B
*	*Psilurus incurvus* (Gouan.) Schintz *et* Thell.	G	G
	Pteridium aquilinum L.	E	F
*	*Quercus alnifolia* Poech. (eat acorns only)	T	Qa
	Quercus coccifera L.	T	B
*	*Quercus infectoria* (Oliver) ssp *veneris* (A.Kerner)	T	B
	Ranunculus ficaria L..	E	F
	Rhamnus alaternus L.	T	B
	Rhus coriaria L.	T	F
	Romulea tempskyana Freyn.	E	M
*	*Rubia tenuifolia* Urv.	S	F
*	*Rubus sanctus* Schreb.	S	Rs
	Rumex sp.	E	F
*	*Salvia verbenaca* L.	E	F
*	*Sarcopoterium spinosum* L.	S	F
	Scabious sp.	E	F
	Scilla autumnalis L.	E	M

	Selaginella denticulata L.	E	F
*	*Senecio vulgaris* L.	E	F
	Silene vulgaris Moench.	E	F
	Sinapis alba L.	E	F
	Smilax aspera L.	E	M
*	*Stellaria media* L.	E	F
*	*Styrax officinalis* L.	T	So
	Tamus communis L.	S	F
*	*Taraxacum* spp.	E	F
*	*Teucrium kotschyanum* Poech.	S	Tk
	Thymus capitatus L.	S	F
	Thymus integer Griseb.	E	F
	Tolpis barbata L.	E	F
*	*Tragopogon sinuatus* Ave-Lall.	E	F
*	*Trifolium* spp.	E	F
*	*Trifolium clypeatum* L.	E	PT
*	*Trifolium leucanthum* M. Bieb.	E	F
	Trifolium pamphylicum (Bois *et* Heldr.)	E	F
	Trifolium pilulare Boiss.	E	F
	Trifolium stellatum L.	E	F
*	*Urginea maritima* L.	E	M
*	*Vicia cassia* Boiss.	E	F
	Vicia hybrida L.	E	F
	Vicia lunata Boiss.	E	F
*	*Vicia pubescens* (DC) Link.	E	F
	Viola sp.	E	F
*	*Vitis vinifera* (L.)	T	B

Appendix 3

Nutrient content of plant species by month.

H20=moisture content, Dig=in vitro digestibility, Crude protein=nitrogen x 6.25, P= phosphorus, K=Potassium. All measurements as % of dry weight except moisture content. lf=leaf; st=stem, fr=fruit, fl=flowers.

Species	Month	H20	Dig	Crude protein	P	K
Cedrus libani	JAN	46.41	37.27	8.00	0.12	0.52
	FEB	-	-	7.75	0.14	0.46
	APR	-	-	5.83	0.45	0.67
	JUN	-	-	6.62	0.14	0.82
	AUG	-	-	4.69	0.09	0.66
	OCT	-	-	4.47	0.18	0.64
	NOV	-	55.07	6.25	0.11	1.01
Pinus brutia lf	JAN	51.06	29.45	5.12	0.12	0.26
	FEB	49.49	34.19	7.12	0.11	0.33
	APR	64.41	42.97	7.25	0.17	0.65
	JUN	62.33	42.79	6.00	0.12	0.59
	AUG	61.74	42.44	4.56	0.09	0.73
	OCT	48.71	32.64	3.87	0.08	0.61
	NOV	50.82	33.28	-	-	-
" " fl	FEB	50.35	31.97	-	-	-
	APR	56.64	43.14	9.37	0.22	1.09
	JUN	61.58	38.87	-	-	-
	AUG	55.44	41.87	-	-	-
	OCT	18.21	35.95	-	-	-
Juglans regia	APR	64.87	46.22	12.91	0.50	2.07
	JUN	-	-	15.41	0.19	2.21
	AUG	-	-	15.50	0.15	1.29
	OCT	-	-	7.62	0.13	1.28
Alnus orientalis	APR	80.02	59.31	17.83	0.23	1.03
	JUN	71.31	55.80	17.22	0.18	1.10
	AUG	66.44	53.94	17.37	0.17	0.85
	OCT	67.57	53.80	12.81	0.10	0.73
	NOV	-	-	14.19	0.13	0.60
Quercus infectoria lf	APR	71.10	44.01	17.85	0.30	1.28
	JUN	68.93	47.91	10.22	0.15	0.92
	AUG	66.76	51.63	8.87	0.19	0.71
	OCT	65.64	47.54	8.19	0.10	0.66
	NOV	59.33	51.49	7.62	0.51	0.65

			Month	H20	Dig	CP	P	K
Q. alnifolia lf			JAN	59.40	36.06	5.69	0.07	0.38
			FEB	-	-	6.06	0.06	0.30
			APR	71.01	56.24	6.47	0.31	0.43
			JUN	57.10	43.73	5.69	0.08	0.66
			AUG	49.56	43.07	2.81	0.06	0.74
			OCT	50.36	40.60	5.44	0.06	0.64
			NOV	50.35	46.59	-	-	-
			FEB	35.79	30.75	-	-	-
			APR	37.74	37.59	-	-	-
			JUN	52.05	41.22	-	-	-
			AUG	41.13	25.37	5.37	-	-
			OCT	41.62	32.54	3.06	-	-
"	"	fruit	AUG	-	35.10	4.94	0.10	0.96
			OCT	-	-	-	0.05	0.66
"	"	caps	AUG	51.79	34.92	-	0.04	0.67
			OCT	56.40	43.47	-	-	-
			NOV	26.35	44.04	-	0.06	0.60
Ficus carica			APR	-	-	-	0.79	2.50
			JUN	-	-	-	0.19	2.24
			AUG	-	-	-	0.35	2.46
			OCT	-	-	-	0.06	1.18
			APR	83.02	-	28.50	-	-
			JUN	76.11	78.39	14.75	-	-
			AUG	52.11	84.24	22.32	-	-
			OCT	76.14	66.96	6.94	0.06	1.13
			OCT	-	81.46	6.75	-	-
Rumex sp.			JAN	89.05	70.56	19.62	0.47	4.68
			FEB	-	-	22.12	0.50	4.52
			APR	-	-	26.44	0.46	3.12
			OCT	-	68.55	-	-	-
Stellaria media			JAN	92.15	73.76	14.25	0.37	3.19
			FEB	87.62	68.13	15.69	0.57	6.02
			APR	86.98	54.11	15.22	0.24	2.51
			FEB	90.36	75.61	-	-	-
			APR	61.24	70.24	9.75	0.37	3.43
Silene vulgaris			JAN	86.63	76.18	16.37	0.31	7.00
			FEB	-	-	20.37	0.56	5.80
			APR	85.33	75.12	21.56	0.44	6.39
			NOV	-	-	25.94	0.41	7.57
"	"		JAN	-	-	-	-	7.12
			FEB	89.46	74.66	-	-	6.39
			APR	87.31	78.41	-	-	7.28
			NOV	91.27	72.09	-	-	-
Ranunculus ficaria			JAN	88.74	76.88	18.19	0.43	3.63
			FEB	-	-	18.50	0.52	4.68
Capsella bursa-pastoris			FEB	89.95	73.31	-	-	-
			APR	-	-	8.62	0.40	1.68

	Month	H20	Dig	CP	P	K
Sinapis alba	JAN	85.85	80.80	24.81	0.70	3.57
	FEB	-	-	21.69	0.47	2.96
	APR	88.27	-	26.50	0.34	2.88
	FEB	84.05	86.71	-	-	-
	APR	84.90	82.16	29.00	0.67	2.70
Platanus orientalis	APR	83.12	77.64	20.2083	0.40	1.54
	JUN	-	-	9.281	0.13	0.87
	AUG	-	-	8.06	0.09	1.05
	OCT	-	-	9.75	0.15	1.68
	NOV	-	-	8.37	0.09	0.68
Rubus sanctus	JAN	57.15	57.94	10.25	0.46	0.77
	FEB	-	-	9.87	0.23	0.70
	APR	73.50	40.69	19.77	0.38	1.72
	JUN	63.42	31.09	11.78	0.27	1.34
	AUG	62.87	30.78	8.32	0.05	0.90
	OCT	68.66	29.67	6.03	0.09	0.60
	NOV	62.20	23.69	1.06	0.14	0.76
	FEB	50.08	50.56	-	-	-
	APR	75.45	58.53	1.50	0.32	1.31
	JUN	71.60	49.74	-	-	-
	AUG	58.53	42.86	-	-	-
	OCT	52.54	47.21	-	-	-
	NOV	54.09	47.64	-	-	-
Poterium verrucosum	JAN	76.96	65.91	16.44	0.33	1.85
	FEB	-	-	14.50	0.28	1.58
	APR	75.20	-	13.50	0.28	1.42
	NOV	-	0.70	19.94	0.39	1.97
Crateagus azarolus	JAN	59.83	50.11	8.56	0.17	0.93
	FEB	6.81	64.22	13.12	0.51	1.70
	APR	50.72	60.13	7.96	0.17	1.54
	JUN	-	-	14.72	0.21	1.57
	AUG	-	-	5.00	0.06	1.11
	OCT	-	-	5.03	0.05	0.77
	NOV	77.20	-	4.50	0.05	0.65
C. monogyna	FEB	68.08	61.86	-	-	-
	APR	70.90	51.15	8.56	0.28	1.79
	JUN	55.58	46.83	-	-	-
	AUG	49.27	47.24	-	-	-
	OCT	49.26	47.43	1.78	0.05	0.80
	NOV	53.25	48.34	1.94	-	-
Calycotome villosa	APR	70.74	58.21	25.12	0.20	1.42
	JUN	-	-	18.00	0.11	0.98
	OCT	-	51.56	-	0.07	0.83
	NOV	-	-	-	0.05	0.77
	JUN	-	-	18.81	0.11	0.99
	OCT	66.82	49.62	-	-	-
	NOV	68.54	49.73	-	-	-
Genista sphacelata	APR	76.49	74.84	16.19	0.21	1.67
	JUN	57.60	71.61	-	-	-

	Month	H20	Dig	CP	P	K
Astragalus lusitanicus	FEB	-	-	26.37	-	-
	APR	-	-	13.44	0.26	1.16
	JUN	-	-	13.75	0.08	1.22
	AUG	-	-	2.94	0.05	0.59
	OCT	-	-	3.81	0.03	0.70
" "	JAN	-	-	-	-	-
	FEB	-	-	-	0.46	1.66
	APR	76.99	68.13	-	0.28	1.25
Vicia cassia	JAN	77.91	73.70	23.12	0.35	1.88
	FEB	79.01	64.82	25.50	0.31	2.14
	APR	61.74	48.78	18.12	0.21	2.08
	JUN	74.57	48.02	-	-	-
	AUG	59.87	40.39	-	-	-
	OCT	8.70	46.93	-	-	-
	NOV	-	-	33.19	0.39	2.10
V. pubescens	JAN	-	-	-	-	-
	FEB	81.56	71.15	-	-	-
	APR	79.09	68.92	13.66	0.21	1.80
	NOV	83.72	70.73	-	-	-
V. hybrida	JAN	83.91	71.88	27.32	-	-
	FEB	-	-	24.87	0.32	2.39
	APR	75.00	71.35	17.94	0.27	2.53
V. lunata	JAN	-	-	-	0.32	1.97
	FEB	85.33	72.14	-	-	-
	APR	83.82	68.84	14.94	0.20	2.00
Lathyrus aphaca	JAN	-	-	-	-	-
	APR	84.27	80.22	17.81	0.34	1.81
Medicago ssp.	JAN	-	-	-	-	-
	APR	79.21	-	8.85	0.17	1.20
	JUN	-	-	10.32	0.14	1.28
Trifolium stellatum	JAN	-	-	-	-	-
	APR	69.35	58.59	14.03	0.13	1.15
	JUN	3.85	52.82	-	-	-
" " lf	JAN	-	-	-	-	-
	APR	64.38	-	-	-	-
	AUG	8.33	-	8.81	0.13	0.57
" " st	JAN	-	-	-	-	-
	APR	-	52.50	9.19	0.22	2.18
	AUG	-	64.76	4.37	0.05	0.97
T. pamphylicum lf	JAN	-	-	-	-	-
	APR	-	64.26	-	-	-
	JUN	-	-	11.19	0.22	0.94
	AUG	-	51.87	-	-	-
" " st	JAN	-	-	-	-	-
	APR	-	59.42	-	-	-
	JUN	6.55	57.11	5.32	0.12	0.21

	Month	H20	Dig	CP	P	K
T. leucanthum lf	JAN	-	-	-	-	-
	APR	-	-	16.94	0.17	1.08
	JUN	-	53.72	-	-	-
" " st	JAN	-	-	-	-	-
	APR	63.77	63.34	9.37	0.11	1.73
T. clypeatum lf	FEB	-	-	24.32	0.55	4.39
	APR	-	58.41	15.72	0.21	1.98
	JUN	-	-	11.06	0.22	1.43
" " st	JAN	-	-	-	-	-
	FEB	88.29	-	-	-	-
	APR	81.19	63.95	8.94	0.19	2.37
	JUN	12.14	65.41	6.00	0.07	2.23
T. pilulare	JAN	-	-	-	-	-
	APR	-	69.11	14.75	0.20	1.39
	JUN	-	56.97	12.69	0.31	1.58
Trifolium spp.	JAN	-	-	21.32	0.27	2.57
	APR	65.15	48.88	26.81	0.48	2.33
	JUN	4.22	57.80	-	-	-
	NOV	-	-	24.81	0.33	2.21
" "	JAN	82.56	74.20	-	-	-
	APR	80.99	82.90	16.37	0.31	1.23
	NOV	87.02	-	-	-	-
Lotus sp. lf	JAN	-	-	14.69	0.15	1.39
	FEB	-	-	18.25	0.19	2.20
	APR	82.09	-	15.56	0.22	2.04
" " st	JAN	88.14	82.19	-	-	-
	FEB	85.66	79.11	-	-	-
	APR	84.77	74.27	7.81	0.13	1.57
Rhus coriaria	JAN	-	-	-	-	-
	APR	-	65.40	18.12	0.40	1.80
	JUN	-	-	12.19	0.18	1.02
	AUG	-	-	9.56	0.08	0.72
	OCT	-	-	7.59	0.47	0.54
	NOV	-	-	4.37	0.04	0.59
Pistacia terebinthus	JAN	-	-	-	-	-
	APR	72.23	64.52	20.54	0.47	1.85
	JUN	66.79	62.86	8.03	0.11	0.60
	AUG	52.06	43.07	11.19	0.12	0.58
	OCT	50.62	56.66	8.09	0.42	0.59
	NOV	55.87	59.39	6.56	0.51	0.54
" "	JAN	-	-	-	-	-
	APR	73.17	56.69	-	-	-
	JUN	56.61	35.82	6.50	0.10	1.36
	AUG	55.60	-	-	-	-
	OCT	50.84	34.46	-	-	-
	NOV	50.49	32.73	-	-	-
" "	JAN	-	-	-	-	-
Acer obtusifolium	JAN	-	-	8.69	0.28	0.57
	FEB	-	-	7.50	0.12	0.54
	APR	-	-	12.06	0.26	1.34
	JUN	68.61	54.85	6.44	0.13	0.71
	AUG	-	-	4.56	0.07	0.73
	OCT	-	-	5.62	0.10	0.50
	NOV	-	-	7.62	0.08	0.53

	Month	H20	Dig	CP	P	K
Vitis vinifera	JAN	43.24	40.56	11.12	0.22	1.41
	FEB	44.05	47.74	-	-	-
	APR	71.35	65.54	26.32	0.48	1.32
	JUN	48.94	48.24	9.50	0.29	1.37
	AUG	45.66	49.56	12.25	0.20	0.95
	OCT	41.88	47.89	6.75	0.26	1.16
	NOV	48.74	44.17	-	-	-
Cistus creticus	JAN	75.83	55.94	12.06	0.31	0.88
	FEB	-	-	7.62	0.15	0.59
	APR	80.96	64.85	11.06	0.30	1.23
	JUN	77.18	54.65	6.19	0.18	0.85
	AUG	68.35	56.32	1.56	0.24	1.09
	OCT	66.13	50.51	5.94	0.11	0.56
	NOV	-	-	9.81	0.24	0.89
C. salviifolius	JAN	72.62	31.02	-	-	-
	FEB	60.34	35.95	6.56	0.11	0.77
	APR	69.47	43.80	7.64	0.22	0.96
	JUN	60.54	36.76	6.97	0.19	1.07
	AUG	37.98	36.44	7.56	0.07	0.76
	OCT	44.42	37.83	5.32	0.06	0.68
	NOV	66.87	35.32	-	-	-
Myrtus communis	JAN	-	-	-	-	-
	FEB	69.37	43.49	-	-	-
	APR	70.77	47.74	4.25	0.07	0.41
	JUN	63.11	38.92	7.56	0.14	1.24
	AUG	57.38	44.55	6.37	0.07	1.06
	OCT	44.70	36.43	7.50	0.07	1.24
Smyrnum connatum	JAN	-	-	-	-	-
	APR	48.82	48.43	21.81	0.33	2.93
	JUN	67.01	53.78	-	-	-
	AUG	47.84	48.49	-	-	-
	OCT	59.39	43.16	-	-	-
Orlaya daucoides lf	JAN	-	-	18.56	-	-
	FEB	-	-	17.19	-	-
	APR	82.80	-	20.06	-	-
	AUG	-	75.93	-	-	-
	NOV	-	-	26.00	0.61	4.87
" " lf	JAN	-	-	-	0.11	3.11
	FEB	-	-	20.56	0.72	4.76
	APR	-	-	18.69	0.25	3.51
	JUN	-	-	12.75	0.24	3.57
	AUG	-	-	9.56	0.17	2.67
	NOV	-	75.70	20.87	0.40	5.07
" " fl	JAN	86.87	56.80	-	-	-
	FEB	84.60	79.81	-	0.77	3.31
	APR	82.78	79.30	18.06	0.67	3.32
	JUN	8.34	75.81	18.69	0.64	2.61
	AUG	9.47	-	-	-	-
	NOV	87.48	78.06	-	-	-
" " fr	JAN	-	-	-	-	-
	FEB	86.16	73.93	-	-	-
	APR	84.93	80.72	-	-	-
	JUN	-	55.16	-	-	-

	Month	H20	Dig	CP	P	K
Arbutus andrachne lf	JAN	-	-	7.44	0.17	0.31
	FEB	-	-	6.06	0.08	0.45
	APR	-	-	9.54	0.21	0.91
	JUN	42.89	-	8.66	0.17	0.88
	AUG	-	-	5.69	0.10	0.56
	OCT	-	-	5.25	0.09	0.41
	NOV	-	-	6.62	0.11	0.46
" " fl,fr	JAN	56.52	36.67	-	-	-
	FEB	51.67	40.44	9.32	0.24	1.22
	APR	65.60	48.55	6.50	0.18	1.05
	JUN	65.15	47.77	7.19	0.22	1.33
	AUG	52.37	46.92	6.50	0.15	0.98
	OCT	49.50	40.58	-	-	-
	NOV	52.80	-	3.44	0.12	0.94
" " fr	JAN	-	-	-	-	-
	FEB	73.24	47.19	-	-	-
	APR	69.95	46.22	-	-	-
	JUN	-	44.78	-	-	-
	AUG	-	36.57	-	-	-
	NOV	-	52.64	-	-	-
Styrax officinalis lf	JAN	-	-	-	-	-
	APR	-	-	16.37	0.29	1.30
	JUN	69.63	-	11.62	0.08	0.96
	AUG	53.09	-	10.25	0.11	0.83
	OCT	-	-	6.44	0.05	0.78
	NOV	62.83	-	4.81	0.05	0.31
" " lf	JAN	-	-	-	-	-
	APR	73.81	64.98	-	-	-
	JUN	64.08	49.98	-	-	-
	AUG	59.87	48.49	2.94	-	-
	OCT	46.01	43.91	3.84	-	-
	NOV	58.96	42.91	-	-	-
" " fr	JAN	-	-	-	-	-
	AUG	-	50.66	-	0.05	0.85
	OCT	-	-	-	0.06	0.87
Gallium aparine	JAN	-	-	-	-	-
	APR	-	-	10.94	0.39	2.48
	AUG	65.31	47.11	-	-	-
	OCT	65.82	55.22	-	-	-
Anchusa sp. lf	JAN	-	-	14.69	0.44	2.3
	APR	83.78	-	16.87	0.41	4.015
" " fl	JAN	83.71	32.94	-	-	-
	APR	86.40	55.23	0.12	-	-
" " st	JAN	-	-	-	-	-
	APR	-	-	17.12	0.37	3.86
Teucrium kotschyanum leaf.	JAN	-	-	7.32	0.13	1.06
	FEB	-	-	10.37	0.32	1.44
	APR	-	-	11.8	0.39	1.33
	JUN	-	-	6.78	0.38	2.17
	AUG	-	-	6.32	0.16	1.20
	OCT	-	-	6.94	0.15	0.95
	NOV	-	-	6.50	0.09	1.21

	Month	H20	Dig	CP	P	K
Teucrium kotschyanum stem.	JAN	65.77	56.05	-	-	-
	FEB	74.04	63.38	-	-	-
	APR	75.28	62.14	-	-	-
	JUN	77.52	62.55	6.19	0.31	2.12
	AUG	56.98	44.64	7.44	0.05	1.86
	OCT	34.18	49.19	3.00	0.02	1.62
	NOV	66.08	55.03	-	-	-
Phlomis cypria	JAN	-	-	-	-	-
	APR	-	-	9.56	0.26	1.71
	JUN	-	56.16	-	-	-
	AUG	-	37.17	-	-	-
	OCT	-	32.07	-	-	-
Menthes longifolia	JAN	-	-	-	-	-
	APR	-	-	-	0.35	2.57
Salvia verbenaca lf	JAN	-	-	18.81	0.30	2.80
	FEB	-	-	16.06	0.54	3.89
	APR	-	-	16.19	0.32	3.08
	NOV	-	-	17.06	0.38	2.21
" " fl	JAN	86.84	55.38	14.00	0.37	2.14
	FEB	83.08	57.35	-	-	-
	APR	83.37	58.27	16.69	0.39	2.70
	NOV	88.19	62.73	19.69	0.42	2.29
Menthes longifolia	JAN	77.42	55.97	-	-	-
	APR	80.80	55.90	30.75	0.35	2.57
	NOV	82.38	68.98	-	-	-
Lonicera etrusca	JAN	-	-	18.62	0.27	1.37
	FEB	-	-	12.50	0.21	1.52
	APR	89.74	68.87	11.39	0.16	1.40
	JUN	-	-	10.72	0.21	2.57
	AUG	-	-	6.56	0.09	1.81
	OCT	-	-	5.12	0.07	1.78
	NOV	-	-	10.94	0.22	1.27

	Month	H20	Dig	CP	P	K
Chamomile	JAN	76.14	56.30	-	-	-
	FEB	70.25	52.11	-	-	-
	APR	71.35	59.62	10.81	0.36	2.34
	JUN	73.93	60.33	-	-	-
	AUG	67.29	49.33	-	-	-
	OCT	61.55	56.00	-	-	-
	NOV	73.42	63.23	-	-	-
Inula viscosa	JAN	-	-	-	-	-
	FEB	-	-	12.12	0.22	1.11
	APR	80.25	72.76	13.12	0.27	1.37
Senecio vulgaris	JAN	-	-	15.06	0.47	2.68
	FEB	73.66	53.19	11.25	0.39	2.62
	APR	74.60	42.79	-	-	-
Calendula arvensis	JAN	84.13	75.42	19.69	0.38	3.77
	FEB	80.29	73.93	12.56	0.33	3.64
	APR	-	-	9.25	0.42	2.51
	NOV	-	-	20.44	0.62	3.09
Large composite lf	JAN	91.24	77.84	-	-	-
	FEB	88.16	76.02	-	-	-
	APR	82.05	71.46	2.44	0.63	2.54
	AUG	-	-	10.25	0.23	1.99
	NOV	91.04	64.06	-	-	-
" " st	JAN	-	-	-	-	-
	APR	88.74	-	7.56	0.29	1.30
	AUG	82.35	-	7.06	0.11	1.56
" " fl	JAN	-	-	-	-	-
	APR	-	-	-	0.58	2.46
	AUG	-	45.29	-	-	-
" " lf	JAN	-	-	-	-	-
	JUN	-	-	8.56	0.37	2.49
" " lffl	JAN	-	-	-	-	-
	JUN	78.80	61.81	7.06	0.29	2.00
" " st	JAN	-	-	-	-	-
	APR	84.22	-	-	-	-
	JUN	25.62	60.30	4.62	0.31	1.83
" " st	JAN	-	-	-	-	-
	JUN	-	42.60	2.62	0.18	1.06
Composite sp. lf	JAN	-	-	-	-	-
	JUN	-	43.11	-	-	-
Large composite lf	JAN	-	-	13.87	0.33	2.71
	FEB	-	-	19.50	0.55	4.44
	APR	-	-	10.44	0.25	3.85
	JUN	27.49	-	20.56	0.18	3.59
	NOV	-	-	19.06	-	2.64
" " st	JAN	88.48	78.40	-	-	-
	FEB	89.00	76.64	-	-	-
	APR	87.56	67.87	-	-	-
	JUN	82.75	58.21	7.37	0.24	2.67
	OCT	15.16	59.21	2.62	0.20	1.79
	NOV	90.15	76.02	-	-	-

	Month	H20	Dig	CP	P	K
Large composite fr	JAN	-	-	-	-	-
	JUN	-	55.91	11.69	0.37	2.13
	OCT	-	40.07	5.44	0.36	2.7
Small composite lf	JAN	-	-	-	-	-
	APR	-	-	18.25	0.16	2.46
	JUN	77.24	62.89	-	-	-
" " st	JAN	90.09	-	-	-	-
	FEB	88.74	-	-	-	-
	APR	86.02	-	8.62	0.51	2.41
	OCT	90.75	-	-	-	-
	NOV	89.75	-	-	-	-
" " fr	JAN	-	-	-	-	-
	APR	81.68	-	17.32	0.63	2.01
Taraxacum spp. lf	JAN	-	-	15.32	0.58	4.01
	FEB	-	-	19.94	0.54	3.85
	APR	-	74.33	11.12	0.23	2.88
	OCT	-	-	-	0.38	4.64
	NOV	-	-	-	0.31	3.54
" " fl	JAN	-	74.74	-	-	-
	FEB	-	70.22	-	-	-
	APR	-	67.98	13.94	0.42	2.42
	OCT	-	73.67	18.37	-	-
	NOV	-	66.96	18.56	-	-
Asphodelus aestivuslf	JAN	-	-	18.87	0.29	1.29
	FEB	-	-	11.69	0.28	3.69
	APR	-	67.76	11.06	0.19	2.55
	JUN	-	-	2.12	0.01	1.05
	AUG	-	-	1.62	0.03	2.02
	OCT	-	-	2.12	0.02	0.21
" " fl	JAN	80.77	79.15	-	-	-
	FEB	87.85	79.67	18.69	0.52	2.59
	APR	81.04	70.04	19.00	0.49	2.47
	JUN	12.77	72.57	-	-	-
	AUG	11.52	59.90	-	-	-
	OCT	29.31	69.19	-	-	-
Urginea maritima	JAN	-	-	-	-	-
	FEB	79.58	76.89	-	-	-
	APR	84.21	-	-	0.21	3.41
	JUN	-	-	4.62	0.07	0.53
	AUG	-	-	2.44	0.09	1.41
Muscari comosum lf	JAN	-	-	-	-	-
	APR	-	-	14.34	0.28	2.50
	JUN	7.38	76.73	-	-	-
	AUG	8.52	68.58	-	-	-
" " fl,st	JAN	-	-	-	-	-
	APR	91.15	81.27	15.34	0.31	4.88
Narcissus tazetta	JAN	-	-	16.94	0.58	2.55
	FEB	-	-	11.32	0.33	2.68
	APR	91.20	80.895	-	-	-

	Month	H20	Dig	CP	P	K
Poa sp.	JAN	89.37	77.44	-	-	-
	FEB	84.62	80.31	-	-	-
	APR	-	-	8.32	0.23	1.65
Poa bulbosa	JAN	-	-	-	-	-
	FEB	-	-	9.62	0.23	1.93
	APR	73.05	-	6.90	0.20	1.29
	JUN	-	-	2.03	0.08	0.77
	AUG	-	-	3.75	0.11	0.02
	OCT	-	-	2.94	0.05	0.21
	NOV	-	-	17.75	0.32	2.67
" " st	JAN	-	-	-	-	-
	FEB	74.26	73.94	-	-	-
	APR	67.96	56.50	3.37	0.16	1.14
	JUN	6.46	46.99	-	-	-
	AUG	9.75	56.85	-	-	-
	OCT	10.35	-	-	-	-
	NOV	75.91	-	-	-	-
" " st	JAN	-	-	-	-	-
	APR	-	-	6.19	0.17	0.95
	JUN	-	-	1.62	0.09	0.68
	AUG	-	-	2.06	0.06	0.78
	OCT	-	-	2.50	0.04	0.35
" " fl	JAN	-	-	-	-	-
	APR	-	53.38	14.87	0.45	1.89
	JUN	-	41.83	-	-	-
	AUG	-	44.06	-	-	-
" " fl	JAN	-	-	-	-	-
	APR	-	-	11.97	0.29	1.33
	JUN	-	-	5.03	0.19	0.67
	AUG	-	-	9.19	0.28	0.76
	OCT	-	-	8.19	0.17	0.29
Dactylis glomerata lf	JAN	-	-	-	-	-
	FEB	-	-	13.62	0.42	3.30
	APR	-	68.07	12.06	0.49	3.02
	JUN	-	66.33	4.00	0.27	1.44
	AUG	-	73.59	1.00	0.06	2.36
	OCT	-	-	13.75	-	-
" " st	JAN	80.18	63.99	-	-	-
	FEB	77.76	65.99	1.62	0.02	0.05
	APR	78.23	66.41	5.44	0.40	3.77
	JUN	33.78	-	1.00	0.03	1.26
	AUG	13.59	55.15	2.00	0.04	1.88
" " fl	JAN	-	-	-	-	-
	APR	-	-	13.75	0.31	1.46
	JUN	-	34.13	6.25	0.14	0.76
	AUG	-	35.05	12.69	0.16	1.03
Cynosurus echinatuslf	JAN	-	-	-	-	-
	FEB	-	-	11.62	0.29	2.89
	APR	-	-	10.98	0.24	2.11
	JUN	-	44.83	4.62	0.11	1.02
	AUG	-	45.06	3.25	0.11	1.56
	OCT	-	-	2.37	0.05	0.28

	Month	H20	Dig	CP	P	K
Cynosurus echinatusst	JAN	-	-	-	-	-
	FEB	82.17	69.06	4.06	0.10	1.05
	APR	66.527	63.85	4.96	0.22	1.53
	JUN	6.58	56.44	2.19	0.07	1.43
	AUG	7.91	57.82	1.37	0.05	1.28
	OCT	14.80	62.35	7.12	0.03	0.39
" " fl	JAN	-	-	-	-	-
	FEB	-	-	3.25	0.06	0.54
	APR	-	60.39	7.50	0.28	1.43
	JUN	-	47.04	8.37	0.28	0.91
	AUG	-	45.79	3.32	0.14	0.83
	OCT	-	-	2.69	0.11	0.27
Psilurus incurvus lf	JAN	-	66.60	-	-	-
	APR	-	62.18	-	-	-
	JUN	-	67.77	-	-	-
	AUG	-	55.21	-	-	-
Briza maxima lf	JAN	-	-	-	-	-
	APR	76.14	-	10.94	0.27	-
	OCT	-	-	-	2.75	-
" " st	JAN	-	-	-	-	-
	APR	84.45	-	5.06	0.22	-
	OCT	-	-	-	2.03	-
" " fl	JAN	-	-	-	-	-
	APR	-	-	8.12	0.32	-
	OCT	-	-	-	1.61	-
Bromus spp lf	JAN	-	-	-	-	-
	FEB	-	-	14.50	0.37	2.94
	NOV	-	-	26.56	0.51	3.47
" " st	JAN	-	-	-	-	-
	FEB	80.34	-	5.94	0.40	2.31
	NOV	86.43	-	-	-	-
lf	JAN	-	-	-	-	-
	OCT	-	-	5.06	0.13	0.28
" " st	JAN	-	-	-	-	-
	OCT	13.18	-	1.56	0.06	0.38
" " fl	JAN	-	-	-	-	-
	OCT	-	49.33	2.32	0.05	0.11
Bromus lf	JAN	-	-	-	-	-
	APR	-	-	9.81	0.24	1.84
	AUG	-	-	1.62	0.09	0.96
" " st	JAN	-	-	-	-	-
	APR	67.77	-	3.19	0.12	1.07
	AUG	9.46	-	2.00	0.03	0.85
" " fl	JAN	-	-	-	-	-
	APR	-	65.30	9.32	0.35	1.87
	AUG	-	-	3.32	0.26	0.83
	OCT	-	45.15	-	-	-
Bromus lf	JAN	-	-	-	-	-
	APR	-	-	13.50	0.44	2.50
	JUN	-	-	2.44	0.15	1.42
	AUG	-	74.89	-	-	-
	OCT	-	-	0.87	0.20	1.81
" " st	JAN	-	-	-	-	-
	APR	74.38	68.98	4.94	0.28	2.04
	JUN	11.47	48.48	1.62	0.09	1.40
	OCT	6.97	50.69	3.19	0.14	1.55

		Month	H20	Dig	CP	P	K
Bromus		JAN	-	-	-	-	-
		APR	-	67.59	10.19	-	-
		JUN	-	42.07	7.87	0.31	0.77
		OCT	-	48.35	1.75	0.18	1.13
Bromus		JAN	-	-	-	-	-
		APR	-	72.56	8.16	0.33	1.22
		JUN	-	74.44	5.62	0.20	0.84
		OCT	-	-	1.25	-	-
"	" st	JAN	-	-	-	-	-
		APR	65.29	-	4.75	0.22	1.03
		JUN	6.73	54.64	2.69	0.13	0.67
		OCT	7.52	63.19	8.32	-	-
"	" fl	JAN	-	-	-	-	-
		APR	-	60.19	8.156	0.23	1.02
		JUN	-	46.66	8.32	0.24	0.76
		OCT	-	-	5.19	-	-
Bromus	lf	JAN	-	-	-	-	-
		JUN	-	73.36	2.32	-	-
		OCT	-	74.28	-	-	-
"	" st	JAN	-	-	-	-	-
		JUN	5.43	-	3.44	-	-
"	" fl	JAN	-	-	-	-	-
		JUN	-	44.89	11.87	-	-
		JUN	-	43.85	1.87	-	-
		APR	-	-	5.94	-	-
		JUN	-	71.67	9.56	-	-
Hordeum	lf	JAN	-	-	-	-	-
		APR	-	-	12.34	0.26	2.67
		JUN	-	-	-	0.14	2.22
Hordeum	lf	JAN	-	-	-	-	-
		APR	64.43	-	4.16	0.23	2.12
		JUN	47.94	60.32	4.44	0.06	4.02
"	st	JAN	-	-	-	-	-
		APR	80.11	60.09	7.78	0.22	1.95
		JUN	-	47.52	-	0.30	1.93
"	st	JAN	-	-	-	0.40	3.38
		FEB	-	-	-	0.45	3.82
		APR	-	-	5.25	0.27	1.91
		JUN	-	65.54	13.69	-	-
"	fl	JAN	-	-	-	-	-
		APR	-	61.12	9.94	0.22	1.63
"	fl	JAN	-	-	-	-	-
		APR	-	-	-	0.32	2.13
Avena ludoviciana	lf	JAN	-	-	17.87	-	-
		FEB	-	-	14.81	-	-
		APR	-	-	10.85	0.17	2.16
		JUN	-	-	8.25	0.16	2.46
		OCT	-	-	10.66	0.30	1.15
		NOV	-	-	14.12	0.41	3.02

		Month	H20	Dig	CP	P	K
Avena ludoviciana	lf	JAN	88.40	70.83	-	-	-
		FEB	84.71	75.38	-	-	-
		APR	80.57	68.17	4.75	0.32	2.92
		JUN	37.94	57.68	2.62	0.29	2.21
		AUG	-	59.57	-	-	-
		OCT	10.15	56.29	-	-	-
		NOV	86.01	76.30	-	-	-
"	" st	JAN	-	-	-	-	-
		APR	-	67.70	6.27	0.23	2.21
		JUN	-	46.25	1.25	0.29	3.07
		OCT	-	53.08	1.94	0.11	1.19
		NOV	-	-	13.69	0.40	2.76
"	" lf	JAN	-	-	-	-	-
		APR	-	65.94	9.32	0.33	1.82
		JUN	-	52.29	7.25	-	-
		OCT	-	48.94	2.87	-	-
"	" fl	JAN	-	-	-	-	-
		APR	-	-	-	0.33	1.59
		JUN	-	-	-	0.24	1.67
		OCT	-	-	-	0.06	0.16
grass	lf	JAN	-	-	-	-	-
		FEB	-	-	14.12	0.26	1.65
		APR	-	-	8.25	0.19	2.07
"	" st	JAN	-	-	-	-	-
		FEB	62.98	61.58	12.69	0.24	1.16
		APR	68.81	-	5.06	0.14	1.29
Grass	lf	JAN	-	-	-	-	-
		APR	-	62.37	10.81	0.30	1.66
		JUN	-	-	9.69	0.18	0.98
		AUG	-	-	4.37	0.12	0.90
"	" st	JAN	-	-	-	-	-
		APR	-	-	8.00	0.25	1.57
		JUN	5.87	52.07	62.32	0.09	0.86
		AUG	8.22	58.23	-	-	-
Grass		JAN	-	-	-	-	-
		JUN	-	54.17	8.62	0.38	1.13
		AUG	-	52.23	5.75	0.10	0.60
"		JAN	-	-	-	-	-
		JUN	-	71.14	-	-	-
		AUG	-	78.95	-	-	-
"		JAN	-	-	-	-	-
		AUG	-	64.40	-	-	-
		OCT	6.42	-	-	-	-

Appendix 4

Nutrient content of different plant types. H20=moisture content. Dig=in vitro dry matter digestibility. Crude protein= % nitrogen x 6.25. P=phosphorus. K=potassium. All as % of dry weight except moisture content.

Plant type	Month	H20	Dig.	Crude protein	P	K
Asphodelus aestivus	JAN	80.77	79.15	18.87	0.29	1.29
	FEB	83.71	78.28	15.19	0.40	3.14
	APR	82.62	70.04	15.03	0.34	2.51
	JUN	12.77	72.57	2.12	0.01	1.05
	AUG	11.52	59.9	1.62	0.03	2.02
	OCT	29.31	69.19	2.12	0.02	0.21
	NOV	-	-	-	-	-
Astragalus lusitanicus	JAN	-	-	-	-	-
	FEB	-	-	26.37	0.46	1.66
	APR	76.99	68.13	13.44	0.27	1.20
	JUN	-	-	13.75	0.08	1.22
	AUG	-	-	2.94	0.05	0.59
	OCT	-	-	3.81	0.03	0.7
	NOV	-	-	-	-	-
Broadleaved trees	JAN	58.53	44.39	9.08	0.22	0.76
	FEB	47.86	44.09	6.78	0.10	0.49
	APR	73.34	56.42	17.86	0.33	1.32
	JUN	64.77	49.69	11.74	0.19	1.20
	AUG	58.19	48.08	12.37	0.15	0.85
	OCT	56.85	51.77	7.60	0.12	0.84
	NOV	52.80	47.42	9.02	0.21	0.56
Cedrus libani	JAN	46.41	37.27	8.00	0.12	0.52
	FEB	49.49	34.19	7.75	0.14	0.46
	APR	64.41	42.96	5.83	0.45	0.67
	JUN	62.33	42.79	6.62	0.14	0.82
	AUG	61.74	42.44	4.69	0.09	0.66
	OCT	48.71	32.64	4.47	0.18	0.64
	NOV	50.82	33.28	6.25	0.11	1.01
Cistus spp.	JAN	72.62	31.02	12.06	0.31	0.88
	FEB	64.85	39.72	7.09	0.13	0.68
	APR	70.12	45.77	9.35	0.26	1.10
	JUN	61.83	37.84	6.58	0.19	0.96
	AUG	47.68	40.49	4.56	0.15	0.92
	OCT	44.56	37.13	5.62	0.09	0.62
	NOV	66.87	35.32	9.81	0.24	0.89
Forbs	JAN	83.83	68.00	17.66	0.36	3.08
	FEB	79.59	70.25	17.70	0.45	3.48
	APR	79.45	66.33	14.92	0.33	2.45
	JUN	52.06	57.37	10.56	0.24	1.90
	AUG	47.59	55.79	7.65	0.14	1.54
	OCT	52.38	55.03	6.99	0.20	1.71
	NOV	79.95	65.85	18.95	0.33	2.72

		H20	Dig.	Crude protein	P	K
Fruits	JAN	-	-	-	-	-
	FEB	73.24	47.19	9.31	0.24	1.22
	APR	70.34	52.21	7.53	0.23	1.42
	JUN	56.26	44.78	7.19	0.22	1.33
	AUG	56.73	39.53	5.72	0.08	0.86
	OCT	61.11	50.08	1.78	0.05	0.77
	NOV	44.59	48.34	2.73	0.09	0.77
Grasses	JAN	84.29	67.14	17.87	0.40	3.38
	FEB	77.04	69.19	9.62	0.26	1.97
	APR	72.90	63.93	8.19	0.27	1.82
	JUN	18.02	54.32	7.27	0.18	1.41
	AUG	9.786	57.12	3.98	0.11	1.04
	OCT	9.91	55.16	4.45	0.45	0.64
	NOV	82.78	76.30	18.03	0.41	2.98
Pistacia terebinthus/ Trifolium clypeatum	JAN	-	61.05	22.75	0.40	2.12
	FEB	86.03	57.36	21.41	0.56	3.68
	APR	78.53	54.10	18.73	0.37	2.26
	JUN	45.79	52.03	8.53	0.14	1.13
	AUG	55.6	-	11.19	0.12	0.58
	OCT	43.55	38.52	8.48	0.36	0.93
	NOV	67.15	32.73	6.56	0.51	0.54
Non-graminaceous monocots	JAN	89.37	77.44	16.94	0.58	2.55
	FEB	84.62	80.31	11.31	0.33	2.68
	APR	91.18	81.08	14.84	0.27	3.60
	JUN	7.38	76.73	4.62	0.07	0.53
	AUG	8.52	68.58	2.44	0.09	1.41
	OCT	-	-	-	-	-
	NOV	-	-	-	-	-
Myrtus communis	JAN	-	-	-	-	-
	FEB	-	-	-	-	-
	APR	48.82	48.43	4.25	0.07	0.41
	JUN	67.01	53.78	7.56	0.14	1.24
	AUG	47.84	48.49	6.37	0.07	1.06
	OCT	59.39	43.16	7.50	0.07	1.24
	NOV	-	-	-	-	-
Pinus brutia	JAN	51.06	29.45	5.12	0.12	0.26
	FEB	50.35	31.97	7.12	0.11	0.33
	APR	60.75	44.68	8.31	0.20	0.87
	JUN	61.58	38.87	6.00	0.12	0.59
	AUG	55.44	41.87	4.56	0.09	0.73
	OCT	18.21	35.95	3.87	0.08	0.61
	NOV	-	-	-	-	-
Platanus orientalis	JAN	-	-	-	-	-
	FEB	-	-	-	-	-
	APR	73.50	40.66	20.21	0.4	1.54
	JUN	63.42	31.09	9.28	0.13	0.87
	AUG	62.87	30.78	8.06	0.09	1.05
	OCT	68.66	29.67	9.75	0.15	1.68
	NOV	62.20	23.69	8.37	0.09	0.68

		H20	Dig	Crude protein	P	K
Quercus alnifolia	JAN	59.40	36.06	5.69	0.07	0.38
	FEB	35.79	30.75	6.06	0.06	0.30
	APR	37.74	37.59	6.47	0.31	0.43
	JUN	52.05	41.22	5.69	0.08	0.66
	AUG	41.13	25.37	4.09	0.06	0.74
	OCT	41.62	32.54	4.25	0.06	0.64
	NOV	-	-	-	-	-
Rubus sanctus	JAN	57.15	57.94	10.25	0.46	0.77
	FEB	50.08	50.56	9.875	0.23	0.70
	APR	75.32	58.53	10.63	0.35	1.51
	JUN	71.6	49.74	11.78	0.27	1.34
	AUG	58.53	42.86	8.31	0.05	0.90
	OCT	52.54	47.21	6.03	0.09	0.60
	NOV	54.09	24.17	1.06	0.14	0.76
Styrax officinalis	JAN	-	-	-	-	-
	FEB	-	-	-	-	-
	APR	73.81	64.98	16.37	0.29	1.30
	JUN	64.08	49.98	11.62	0.08	0.96
	AUG	59.87	49.57	6.59	0.11	0.83
	OCT	46.01	43.91	5.14	0.05	0.78
	NOV	58.96	42.91	4.81	0.05	0.31
Teucrium kotschyanum	JAN	65.77	56.05	7.31	0.13	1.06
	FEB	74.04	63.38	10.37	0.32	1.44
	APR	75.28	62.14	11.83	0.39	1.33
	JUN	77.52	59.36	6.48	0.34	2.14
	AUG	56.98	40.90	6.87	0.10	1.53
	OCT	34.18	40.63	4.97	0.08	1.29
	NOV	66.08	55.03	6.50	0.09	1.21

Appendix 5 .

Percent frequency of different plant groups found in the faeces in the different valleys throughout the year. MONOCOTS=non-graminaceous monocotyledons; LITHODORA=*Lithodora hispidula*; BROADLEAVES=broadleaved trees; CISTUS=*Cistus* spp.; ASPHODEL=*Asphodelus aestivus*; PISTACIA=*Pistacia terebinthus* and *Trifolium clypeatum*; TEUCRIUM=*Teucrium kotschyanum*; PINE=*Pinus brutia*; RUBUS=*Rubus sanctus*. No data (-)

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	FORBS	MONOCOTS	GRASSES	LITHODORA	BROADLEAF	CISTUS	ASPHODEL	PISTACIA	TEUCRIUM	PINE	RUBUS
JAN	11 04	0 74	19 54	9 96	6 64	19 19	2 20	8 12	23 24	0 38	0
FEB	14 86	3 38	8 78	9 12	3 04	29 39	2 03	5 07	20 95	2 04	1.01
MAR	18 91	3 15	12 03	15.47	1.43	19 20	2.28	0.57	14 33	2 58	9 17
APR	20 57	4 75	16.77	14 24	5.06	8 54	1.90	3 16	21 84	2 85	0.32
MAY	32.17	20 54	10 85	5 81	5.43	11 63	3.10	2.71	4 65	3 10	0
JUN	27 15	30 60	8 19	3 88	9 91	0.43	6.90	5.60	5 60	0 86	0
JUL	24.13	13 02	15 87	5 71	5 08	8 25	7 62	14 92	4 44	0 95	0
AUG	27 80	16 61	9 02	7 94	8 66	1.81	8 30	6.14	11.19	2.52	0
SEP	19 65	14 14	12 76	9 31	6 21	2 41	14 83	13.45	2.76	4 48	0
OCT	.	.	.	.	.	.	.	.	.	.	.
NOV	15 00	13 12	21.25	16 25	3.75	5.00	9 68	9 68	5 94	0.31	0
DEC	22.39	6 72	11.44	16 42	5.72	9 70	6.96	10 94	8.46	1.24	0

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	FORBS	MONOCOTS	GRASSES	LITHODORA	BROADLEAF	CISTUS	ASPHODEL	PISTACIA	TEUCRIUM	PINE	RUBUS
JAN	18 12	14 06	20 00	11.25	9 69	8 44	8.12	2.19	2.81	4.67	0
FEB	19 69	5 88	17.39	14.07	9.21	13 55	10 48	2.81	2 81	4 17	0
MAR	23.24	10.33	16 43	4 93	7.28	17.14	2 56	2.56	9.15	8.33	0
APR	23.85	11.93	20.18	14.37	4.59	9.48	3.87	3.87	1.83	8.12	0
MAY	40.17	31.44	14 85	3.06	3.06	1.31	2.18	2.18	1.31	0 43	0
JUN	30.00	24 80	10 40	1.20	12.8	0.40	3.60	9.20	4.00	3 60	0
JUL	33.33	12.09	22.34	6.23	8.79	1.10	6 59	7.32	0.73	0.73	0
AUG	20.75	12.89	21.70	6.29	16 35	1.26	14.15	5.35	0 63	0 63	0
SEP	24.91	17.84	16.85	4.38	12.46	0	15.15	5.39	0.67	0 34	0
OCT	.	.	.	.	.	.	.	.	.	.	.
NOV	12.12	10.74	16 80	10.74	15.98	1.10	23 97	5.51	1 93	0 83	0.27
DEC	16 30	9.15	20 82	10.41	21.45	0.85	13.25	2.21	2.52	0 85	0

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	FORBS	MONOCOTS	PIA	LITHODORA	BROADLEAF	CISTUS	ASPHODEL	PISTACIA	TEUCRIUM	PINE	RUBUS
JAN	.	.	.	.	.	.	.	.	.	.	.
FEB	27 6	22.78	24.71	7 34	0	2.70	0	7.72	6.74	0	0
MAR	32.88	24.32	20.70	10.81	0	0 45	0	7 66	1.66	0	1.39
APR	26.74	4.81	55 08	2.67	5 88	0.53	0	2.67	1.18	0	0
MAY	.	.	.	.	.	.	.	.	.	.	.
JUN	29.0	19.00	5.0	1.50	27.00	2.00	0	12.5	1.00	0.55	2.73
JUL	.	.	.	.	.	.	.	.	.	.	.
AUG	26.85	17.31	16 61	0.71	16.02	0.16	3.53	6 01	1.42	0.35	0
SEP	33.48	20.09	10.27	0	24.55	1.79	4.91	4.91	0	0	0
OCT	30.65	12.50	27.62	15.32	8.47	0.40	0	4.03	0.40	0	0
NOV	20.85	15.81	20.95	7.35	16.81	1 84	2.57	6 25	0.54	0	0
DEC	24 81	9.69	20.93	12.89	11.63	3.10	1.94	6.59	6.42	0.40	0

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	FORBS	MONOCOTS	GRASSES	LITHODORA	BROADLEAF	CISTUS	ASPHODEL	PISTACIA	TEUCRIUM	PINE	RUBUS
JAN	.	.	.	.	.	.	.	.	.	.	.
FEB	.	.	.	.	.	.	.	.	.	.	.
MAR	.	.	.	.	.	.	.	.	.	.	.
APR	36 68	36.44	12.69	1.33	0	0.44	0	7.56	0.69	1.33	0 69
MAY	40.00	38 97	10.28	2.05	2.56	0.51	0	2 56	1.03	2 00	0
JUN	29.08	25.50	14.34	1.18	11.15	0	2.39	14.74	1.89	0	0
JUL	.	.	.	.	.	.	.	.	.	.	.
AUG	.	.	.	.	.	.	.	.	.	.	.
SEP	29.08	21.51	27.49	1.18	5.56	0 0	0 60	12.35	0 60	0	0.46
OCT	.	.	.	.	.	.	.	.	.	.	.
NOV	.	.	.	.	.	.	.	.	.	.	.
DEC	.	.	.	.	.	.	.	.	.	.	.

Limnitis

	FORBS	MONOCOTS	GRASSES	LITHODORA	BROADLEAF	CISTUS	ASPHODEL	PISTACIA	TEUCRIUM	PINE
JAN	.	.	.	.	.	.	.	.	.	.
FEB	.	.	.	.	.	.	.	.	.	.
MAR	.	.	.	.	.	.	.	.	.	.
APR	.	.	.	.	.	.	.	.	.	.
MAY	46.36	30 17	17.32	0	3.01	0	1.12	0.56	0 56	0
JUN	44 93	34.3	8 21	0	8.70	0	0.48	3.36	0	0
JUL	.	.	.	.	.	.	.	.	.	.
AUG	26.36	25.52	13.61	2.51	12.55	1.25	12 55	2.51	0	2 93
SEP	.	.	.	.	.	.	.	.	.	.
OCT	.	.	.	.	.	.	.	.	.	.
NOV	.	.	.	.	.	.	.	.	.	.
DEC	.	.	.	.	.	.	.	.	.	.

Appendix 6

Preference index E* of each food type throughout the year.

ASPHODEL=*Asphodelus aestivus*; BROADLEAF=broadleaved trees; CISTUS=*Cistus* spp.; PISTACIA=*Pistacia terebinthus and Trifolium clypeatum;* LITHODORA=*Lithodora hispidula;* MONOCOT=all non-graminaceous monocotyledons; PINE=*Pinus brutia*; and RUBUS=*Rubus sanctus.*

$E^* = \frac{w-(1/n)}{w+(1/n)}$ where n=no. of food types, $w = \frac{(r+p)}{\Sigma(r+p)}$, r=% of each food eaten, and p=% of each food in the environment.

Note: the data shown in table 2.2 is for foods and non-foods. When the selectivity index was calculated, only the data for foods were used. The percent availability of each food per month per valley was recalculated from table 2.2 before carrying out the E* calculation.

AYIA VALLEY

MONTH	ASPHODEL	BROADLEAF	CISTUS	FORBS	GRASS	PISTACIA	LITHODORA	MONOCOTS	PINUS BRUTIA	RUBUS	TEUCRIUM
JAN	-0.62	-0.72	-0.33	-0.44	-0.19	0.68	1	-0.77	1	-1	0.57
FEB	-0.55	-0.81	-0.04	-0.09	-0.28	0.44	1	-0.15	1	-0.84	0.66
MAR	-0.54	-0.88	-0.02	0.00	-0.10	1	1	0.14	1	0.15	0.67
APR	-0.84	-0.80	-0.80	-0.65	-0.35	-0.23	1	-0.28	0.66	-0.97	0.59
MAY	-0.45	-0.57	-0.75	-0.40	-0.37	-0.11	1	0.69	1	-1	0.52
JUN	-0.28	-0.67	-0.99	-0.39	-0.56	-0.61	-0.70	0.78	1	-1	0.08
JUL	-0.16	-0.77	-0.78	-0.36	0.01	-0.26	-0.59	0.63	1	-1	0.53
AUG	-0.69	-0.74	-0.95	0.19	0.36	1	1	0.68	1	-1	0.28
SEP	1	-0.31	-0.93	-0.23	-0.05	0.22	1	0.69	1	-1	0.29
OCT	-	-	-	-	-	-	-	-	-	-	-
NOV	0.36	-0.79	-0.85	-0.41	0.02	0.27	1	0.63	1	-1	0.02
DEC	0.15	-0.72	-0.53	-0.07	-0.23	0.53	1	0.46	1	-1	0.25

VROISHA VALLEY

	ASPHODEL	BROADLEAF	CISTUS	FORBS	GRASSES	PISTACIA	LITHODORA	MONOCOTS	PINUS BRUTIA	RUBUS	TEUCRIUM
JAN	0.28	1	-0.37	-0.48	0.04	1	-0.03	0.65	-0.07	-1	-0.12
FEB	0.37	1	-0.05	-0.36	0.01	1	0.38	0.39	0.07	-1	-0.14
MAR	-0.61	1	-0.48	-0.58	-0.36	0.63	-0.40	0.24	0.42	-1	-0.11
APR	-0.28	0.20	-0.40	-0.38	-0.18	0.10	0.41	0.29	0.25	-1	-0.62
MAY	-0.61	-0.70	-0.95	-0.50	-0.39	-0.47	-0.64	0.80	-0.89	-1	-0 85
JUN	-0.63	-0.34	-0.99	-0.61	-0.81	0.53	-0.94	0.72	-0.71	-1	-0.57
JUL	-0.09	1	-0.93	-0.16	0.16	0.19	-0.30	0.60	0.32	-1	-0.85
AUG	-	-	-	-	-	-	-	-	-	-	-
SEP	0.19	0.00	-1	-0.19	-0.43	-0.13	-0.19	0.71	-0.95	0	-0.74
OCT	-	-	-	-	-	-	-	-	-	-	-
NOV	0.74	0.35	-0.97	-0.82	-0.64	1	-0.42	0.13	-0.86	-0.99	-0.77
DEC	-0.37	0.81	-0.99	-0.89	-0.77	1	-0.74	-0.36	-0.93	-1	-0.87

Preference index E* of each food type throughout the year.

ASPHODEL=*Asphodelus aestivus*; BROADLEAF=broadleaved trees; CISTUS=*Cistus* spp.; PISTACIA=*Pistacia terebinthus and Trifolium clypeatum;* LITHODORA=*Lithodora hispidula;* MONOCOT=all non-graminaceous monocotyledons; PINE=*Pinus brutia*; and RUBUS=*Rubus sanctus.*

$E^* = \frac{w-(1/n)}{w+(1/n)}$ where n=no. of food types, $w = \frac{(r+p)}{\Sigma(r+p)}$, r=% of each food eaten, and p=% of each food in the environment.

PIA VALLEY

MONTH	ASPHODEL	BROADLEAF	CISTUS	FORBS	GRASSES	PISTACIA	LITHODORA	MONOCOTS	PINUS BRUTIA	RUBUS	TEUCRIUM
JAN	-	-	-	-	-	-	-	-	-	-	-
FEB	-1	-1	-0.89	-0.48	-0.50	1.00	0.21	0.79	-1	-	1.00
MAR	-1	-1	-0.99	-0.64	-0.74	1.00	0.06	0.81	-1	1.00	1.00
APR	-1	0.25	-0.95	-0.21	0.39	1.00	0.15	0.67	-1	-	1.00
MAY	-	-	-	-	-	-	-	-	-	-	-
JUN	-1	0.44	-0.84	-0.19	-0.76	-0.05	-0.28	0.67	-0.74	1.00	-0.13
JUL	-	-	-	-	-	-	-	-	-	-	-
AUG	0.23	0.17	-0.49	-0.17	-0.15	-0.52	-0.75	0.58	-0.90	-	0.31
SEP	0.23	0.46	-0.92	-0.06	-0.75	1.00	-1	0.70	-1	-	-
OCT	-1	-0.17	-0.98	-0.22	-0.42	1.00	0.70	0.57	-1	-	1.00
NOV	0.54	0.01	-0.95	-0.64	-0.65	1.00	0.19	0.64	-1	-	1.00
DEC	0.19	0.33	-0.88	-0.51	-0.59	1.00	0.63	0.42	-0.87	-	1.00

AYIOS MERCURIOS VALLEY

MONTH	ASPHODEL	BROADLEAF	CISTUS	FORBS	GRASSES	PISTACIA	LITHODORA	MONOCOTS	PINUS BRUTIA	RUBUS	TEUCRIUM
JAN	-	-	-	-	-	-	-	-	-	-	-
FEB	-	-	-	-	-	-	-	-	-	-	-
MAR	-	-	-	-	-	-	-	-	-	-	-
APR	-	-	-	-	-	-	-	-	-	-	-
MAY	0	0.38	-0.96	0.27	-0.51	0.45	1	0.52	-0.07	-1	1
JUN	0.63	0.30	-1	-0.08	-0.87	0.15	1	0.41	-1	-1	1
JUL	-	-	-	-	-	-	-	-	-	-	-
AUG	-	-	-	-	-	-	-	-	-	-	-
SEP	1	0.02	-0.89	-0.22	-0.64	0.59	1	0.67	-1	-0.98	1
OCT	-	-	-	-	-	-	-	-	-	-	-
NOV	-	-	-	-	-	-	-	-	-	-	-
DEC	-	-	-	-	-	-	-	-	-	-	-

Preference index E* of each food type throughout the year.

ASPHODEL=*Asphodelus aestivus*; BROADLEAF=broadleaved trees; CISTUS=*Cistus* spp.; PISTACIA=*Pistacia terebinthus and Trifolium clypeatum;* LITHODORA=*Lithodora hispidula;* MONOCOT=all non-graminaceous monocotyledons; PINE=*Pinus brutia*; and RUBUS=*Rubus sanctus.*

$E^* = \frac{w-(1/n)}{w+(1/n)}$ where n=no. of food types, $w = \frac{(r+p)}{\Sigma(r+p)}$, r=% of each food eaten, and p=% of each food in the environment.

LIMNITIS VALLEY

	ASPHODEL	BROADLEAF	CISTUS	FORBS	GRASSES	PISTACIA	LITHODORA	MONOCOTS	PINUS BRUTIA	TEUCRIUM
JAN	-	-	-	-	-	-	-	-	-	-
FEB	-	-	-	-	-	-	-	-	-	-
MAR	-	-	-	-	-	-	-	-	-	-
APR	-	-	-	-	-	-	-	-	-	-
MAY	-0.89	0.18	-1	-0.63	-0.48	-0.85	-	0.77	-1	1.00
JUN	-0.98	0.42	-1	-0.72	-0.84	-0.67	-	0.75	-1	-1
JUL	-	-	-	-	-	-	-	-	-	-
AUG	-0.29	1.00	-0.98	-0.56	-0.73	-0.85	1.00	0.80	-0.81	-
SEP	-	-	-	-	-	-	-	-	-	-
OCT	-	-	-	-	-	-	-	-	-	-
NOV	-	-	-	-	-	-	-	-	-	-
DEC	-	-	-	-	-	-	-	-	-	-

Appendix 7.

Percent of different food types in the diets of mouflon from Cyprus (CY):this study; from Corsica (CO):Pfeffer 1967; and from Czechoslovakia (CZ):Mottl 1960. *

	Trees			Forbs and grasses			Shrubs			Fruits			Lichens, Mosses, and bark		
	CY	CZ	CO	CY	CZ	CO	CY	CZ	CO	CY	CZ	CO	CY	CZ	CO
Winter	20	29	52	49	8	11	31	27	37	0	12	0	0	24	0
Spring	12	18	17	68	44	33	20	23	50	0	2	0	0	13	0
Summer	27	7	15	65	56	45	8	32	40	0	4	0	0	1	0
Autumn	20	11	37	63	13	13	17	20	49	0	55	0	0	1	0

The seasons were defined as:
Winter=December, January, February;
Spring=March, April, May;
Summer=June, July, August, September;
Autumn=October, November.
In the case of the Cyprus data,
Shrubs=*Cistus, Lithodora, Rubus, Teucrium.*
Forbs & grasses=Forbs, *Asphodelus*, grass, monocots.
Trees=Broadleaved trees, pine trees, plus the *Pistacia terebinthus/Trifolium clypeatum* category.
*Different methods used: Cyprus: faeces analysis; Czechoslovakia: rumen content analysis; Corsica: observations only.

Appendix 8.

GROUP SIZES: showing the actual nos. of animals seen in each category, and the percent of animals seen in each category.

SPRING: total no. of animals=295

Group size	Males Old		Young		Females Single		With young		Mixed groups		All males		All females	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1	29	19.6	8	17.4	9	32.1	7	29.2	*	*	37	19.1	16	30.8
2	32	21.6	14	30.4	12	42.9	10	41.7	4	8.2	46	23.7	22	42.3
3	18	12.2	12	26.1	3	10.7	3	12.5	12	24.5	30	15.5	6	11.5
4+	69	46.6	12	26.1	4	14.3	4	16.7	33	67.3	81	41.8	8	15.4
Total	148		46		28		24		49		194		52	

	No.	%
Mixed	49	16.6
Single sex	246	83.4

SUMMER: total no. of animals=385

Group size	Males Old		Females Young		Single		With young		Mixed groups		All males		All females	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1	23	16.9	20	57.1	11	29.7	22	19.6	*	*	43	25.1	33	22.1
2	28	20.6	12	34.3	12	32.4	22	19.6	4	6.1	40	23.4	34	22.8
3	30	22.1	3	8.6	6	16.2	33	29.5	9	13.8	33	19.3	39	26.2
4+	55	40.4	0	0.0	8	21.6	35	31.2	52	80.0	55	32.2	43	28.9
Total	136		35		37		112		65		171		149	

	No.	%
Mixed	65	16.9
Single sex	320	83.1

AUTUMN: total no. of animals=118

Group size	Males Old		Young		Females Single		With young		Mixed groups		All males		All females	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1	20	54.0	2	100.0	2	14.3	2	33.3	*	*	22	56.4	4	20.0
2	8	21.6	0	0.0	8	57.1	4	66.7	14	23.7	8	20.5	12	60.0
3	9	24.3	0	0.0	0	0.0	0	0.0	12	20.3	9	23.1	0	0.0
4+	0	0.0	0	0.0	4	28.6	0	0.0	33	28.0	0	0.0	4	20.0
Total	37		2		14		6		59		39		20	

	No.	%
Mixed	59	50.0
Single sex	59	50.0

WINTER: total no. of animals=326

Group size	Males Old	Female Young	Single	With young	Mixed groups	All males	All females
	No. %	No. %	No. %	No. %	No. %	No. %	No. %
1	25 13.1	1 2.6	9 30.0	3 42.9	* *	26 11.4	12 32.4
2	34 17.8	8 21.0	6 20.0	4 57.1	8 13.3	42 18.3	10 27.0
3	12 6.3	12 31.6	6 20.0	0 0.0	12 20.0	24 10.5	6 16.2
4+	12062.8	17 44.7	9 30.0	0 0.0	40 66.7	137 59.8	9 24.3
Total	191	38	30	7	60	229	37

	No.	%
Mixed	60	18.4
Single sex	266	81.6